RISK MANAGEMENT FRAMEWORK FOR HIGHWAY CONSTRUCTION PROJECTS IN NIGERIA

By

Sani Reuben Akoh

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Heriot-Watt University

School of Energy, Geoscience, Infrastructures and Society

Edinburgh-United Kingdom

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ABSTRACT

Poor performance of highway construction projects in developing countries can be attributed to the lack of understanding and application of risk management. However, risk and uncertainty of highway projects in the developing countries, particularly in Sub-Saharan Africa, (e.g. Nigeria) has been under-researched compared to countries elsewhere in the world.

Thus, this research aims to develop a new risk management framework to improve the management of highway infrastructure construction projects in Nigeria.

Thirty-five risk factors and risk management processes and techniques were identified through a comprehensive literature review. A questionnaire survey and case study interviews were adopted to seek for the opinions of Nigerian highway experts on the possibility and consequence of occurrence of those risk factors, as well as the risk management processes and techniques currently used. One hundred and twenty-eight questionnaire surveys were completed, and thirteen interviews were conducted on four cases of on-going highway infrastructure construction projects in Nigeria. The criticality of each risk was calculated to determine the top nine most critical risk factors affecting the performance of highway infrastructure construction projects in Nigeria. External risks were found to be more critical and have significant consequence on the performance of highway infrastructure construction projects in Nigeria compared to internal risks.

Based on the findings from the literature reviews, the questionnaire survey and case studies, a new highway project risk management framework has been developed. For each of the top nine most critical risks identified, practical mitigation measures have been developed and evaluated. A semi-structured interview was conducted with 16 Nigerian highways experts involved in four distinct on-going highway infrastructure construction projects in Nigeria to validate the framework. The validation feedback shows that the developed framework is user-friendly, cost effective and suitable for developing countries, as it does not involve complicated processes.

Keywords: Developing countries, highway construction projects, Nigeria, risk identification, risk management

DEDICATION

With Uncontrollable Tears in My Eyes:

To the Blessed Memory of My Mother, **Late Mrs Ojo-Onyi Akoh (Nee Okwori)** and My Father **Pa Akoh Ogala**

To the Blessed Memory of my Brother, **Late Mr. Joseph Akoh**

To the Blessed Memory of My Brother's Wife, **Late Mrs Comfort Ojene Akoh**

To the Blessed Memory of My Father-in-law, **Late Mr. Daniel Owoicho Inedu**

We stand motionless,
consumed in grief.
Sorrow has arrived,

Life without you,
is so hard to conceive.

Our hearts are damaged,
and scarred severely.

Ever since you (**Daniel**) went away

You did so much for me,
as I didn't do much for you.
I hope you will forgive me,
for all the things I didn't do

You are my brother
and my best friend.
I will always love you.
Life has never been the same
We shall miss you,
much more than dearly.

For having you in our lives,
we've all been blessed.
But now the time has arrived,
for you to rest.

It's sad that **Daniel** left
without saying goodbye,
But just remember we all love you.

You have all Sincerely, Laboured, Prayed and wish me well wholeheartedly but have inevitability gone to Rest

How I Wish my Wishes Were True and You are here! **But to my Dismay, you are not here!** God has been My Comfort and Strength! **Adieu**

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I would like to wholeheartedly thank my wife, Ada for her emotional support, love, comfort and courage in the face of unimaginable tragedy in our family. She is ‘an epitome of love’. To my loving and cheerful children: Daniel and David; Victor and Victoria; Albert and Cornelius, thank you very much for your understanding.

DECLARATION OF STATEMENT

ACADEMIC REGISTRY
Research Thesis Submission

Name*:*	Sani Reuben Akoh		
School:	EGIS		
Version: *(i.e. First, Resubmission, Final)*		Degree Sought:	PhD Construction Project Management

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In accordance with the appropriate regulations I hereby submit my thesis and I declare that:

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3) the thesis is the correct version of the thesis for submission and is the same version as any electronic versions submitted*.
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Akoh S R., Sun, M., Ogunlana, S.O., Akoh, S.O., 2018. Addressing the critical risk factors in Nigerian highway infrastructure construction projects. In Journal of Engineering, Construction and Architectural Management (Under review).

Chapter 1: Introduction

1.1 Introduction

The chapter presents an overview of the PhD study which consists of the background to the research, problem statement, research aim and objectives, research methods and an outline of the structure of the thesis.

1.2 Background to the research

Nigeria is the largest country in West Africa, with estimated population of about 170million and a land mass of 924 770 km2 and comprises 36 states and 774 local government areas. Road is the major means of transportation in Nigeria largely due to the insufficiency and ineffectiveness of other means of transportation. According to the International Road Federation (IRF) statistics, Nigeria occupies the top position in term of road network compared to other countries in Sub-Saharan Africa (Onolememen, 2013) and is the leading West African country in terms of road network, with an estimated 200,000km of road network linking urban and rural areas (Okigbo, 2012; Onolememen, 2013). Unfortunately, being rich in oil, Nigeria is politically unstable with inadequate infrastructure coupled with government corruption and poor macroeconomic management.

Successive Nigerian governments have been committed to the construction and expansion of major highways projects in Nigeria. However, in attempting to accomplish this, the challenges encountered by the regime in the provision of better roads have led to many highway infrastructure projects being abandoned. Large infrastructure projects are usually susceptible to many risks, especially in their construction phase. It is therefore very important to understand how to manage risks during the construction phase of such projects. In addition, the management of highway infrastructure projects in Nigeria is very poor and one of the main problems has been identified as the lack of effective risk management (Abdelgawad and Fayek, 2010). Literature review such as Zayed, et al. (2008), Mousavi et al. (2011) and Yirenkyi-Fianko and Chileshe, (2015) have shown that risks and uncertainties associated with highway infrastructure construction projects in developing countries, especially Nigeria, have received little attention from researchers. Thus, this research is driven be the

demand for a more efficient and effective approach to improve the management of highway construction in Nigeria.

Project risk can be described in terms of an uncertain situation which when it happens will result in positive or negative impact on one or more project goals (PMI, 2008). Within the domain of construction project management, risk management is the extensive and well-organized way of identifying, analysing and reacting to risks that may affect project success.

The purpose of risk management is to recognize uncertain situations that might jeopardize the success of construction projects and to develop strategies to decrease the probability of their occurrence. The basic idea of risk management is to manage risk effectively (Lyons and Skitmore, 2004). Risk management is an integral part of project management (Olsson, 2008; Osipova and Eriksson, 2013), and to buttress this view, risk management has been given prominence in one of the nine Knowledge Areas of project management (PMI 2008; PMI 2004). Moreover, it is not always possible, nor desirable, to avoid project risk, particularly if some risks can be turn into opportunities through effective and efficient handling of those risks (Choudhry and Iqbal, 2013).

Ensuring effective delivery of construction projects to meet costs, schedule, performance and environmental sustainability requirements requires identifying and managing the risks to the projects at all project stages from conceptualisation to termination. The construction industry is exposed to more risks and uncertainties compared to other businesses (Dey and Ogunlana, 2004; Zeng et al, 2007). This is as result of the complexities of construction projects and the involvement of many parties with different interest. Instances of many project failures have been related to ineffective and poor risk management (Zou et al., 2007; Abdelgawad and Fayek, 2010). Failure to manage construction project risks effectively, can lead to failure in achieving the desired project objectives, resulting in increased costs, time delays, lack of quality, and issues related to the functionality of the facilities (Choudhry and Iqbal, 2013; Zhang, 2016); flawed planning, possible breakdown in the relationship between the client and the contractors, difficulties in delivering the project and inevitable project delays and cost overruns.

In Nigeria, large-scale infrastructure construction projects are typically associated with enormous budgets over prolonged time-frames and they usually consist of various risk events, such as natural disasters, technical difficulties, insufficient information and

political issues (Fan et al., 2008). Thus, there is a particular need to ensure that the resources have been invested economically, efficiently and effectively and application of risk management is vital to improve the management of highway infrastructure projects.

1.3 Statement of problem

Although there have been considerable efforts in risk management research for large infrastructure projects, there is still a lack of specific investigation on risk management in highway infrastructure construction projects in the context of Nigeria. The literature review conducted in this study shows that although risk management in highway infrastructure projects has been given substantial attention in recent years, risk and uncertainty in highway projects in the developing countries, particularly in Sub-Saharan Africa, (e.g. Nigeria) has been under-researched compared to countries such as the USA, UK, Germany and Australia. Even compared to countries in the Asian region (e.g. China, Iran, and Pakistan), Sub-Saharan Africa has been under-represented in highway construction project risk management research (see Table 2-2). Mousavi et al. (2011) reported that data and experts' comments on Highway project in developing countries are small in quantity and limited. Okigbo (2012) also pointed out that there is a lack of adequate informational data on Nigerian roads. Many instances of poor highway construction project performance in developing countries compared to developed countries occur as a result of lack of understanding and application of risk management. The review of the literature undertaken in this study, as summarised in Table 2-2, shows that complex mathematical models and frameworks have been proposed to address risks affecting the performance of major infrastructure projects in different countries. The applications or practicability of such models or frameworks depends on the project risk management capabilities of an organisation. Unfortunately, the risk management capability of organisations in developing countries such as Nigeria is very poor (Salawu and Abdullah, 2015). Moreover, of the few risk analysis management frameworks that exists, they hardly integrate risk analysis and response development and suffer from poor user-friendliness (Dey, 2012). To manage risk associated with highway construction projects in developing countries effectively and efficiently, a simple but proper and systematic methodology, essentially involving knowledge and experience, is required.

1.4 Rationale, significance and purpose of the research

The Nigerian construction industry is branded with time and cost overruns and this often resulted in outright abandonment of projects (Sonuga et al 2002; Odusami et al 2003). In fact, Sonuga et al (2002) cited Nigeria as a perfect example of a developing country with a large number of abandoned projects. Odeyinka and Yusif (1997) further confirmed that 70% of project surveyed in Nigeria suffered from time overrun in their execution. One of the major reasons for such failures outlined above can be attributed to lack of understanding and effective application of risk management (Choudhry & Iqbal 2012; El-Sayegh & Mansour 2015; Reza et al 2016).

Risk management in Nigerian construction industry is in its embryonic stage and it has not yet been fully explored. Previous research efforts in the area of risk management within the Nigerian context have only been directed toward identifying and evaluating the impact of risk on building projects (Ibrahim et al, 2006; Dada and Jagboro 2007; Ogunsanmi et al 2011; Oyewobi et al 2012). According to the recent study conducted by Salawu and Abdullah (2015) to determine the risk management capability of construction organisation on highway infrastructure projects delivery in south west Nigeria, it was reported that the contractors risk management capability is poor and that almost all the fully and substantially completed highway projects had failed to achieve their original performance objectives. Risk management generally is relatively new in Nigerian construction industry. Hence, it has been under researched and under-represented internationally. Literature reviews have shown that risks and uncertainties associated with highway construction infrastructure projects in developing countries especially Nigeria have received little attentions from researcher. To effectively and efficiently manage risk associated with highway construction projects in Nigeria, a simple but proper and systematic methodology, essentially, knowledge and experience is required.

Although there have been considerable efforts in large infrastructure project risk management research, there is still a lack of specific investigation on risk management in highway construction projects in the context of Nigeria. Nigerian scholars noticeably have paid limited attention to risk management in construction industry compared to their counterpart in other developing country and in the developed nations. The key

challenges that exist in developing countries especially Nigeria is not likely to be the same with that of developed countries.

Nigeria is a country with vast resources spent yearly on construction projects Saka & Lowe (2010). Construction practitioners need to be knowledgeable of risk inherent in construction project and how to deal with it. In as much as risk analysis and management play significant roles in the achievement of projective objective, little is known concerning the industry's response and the techniques employed for risk analysis and management in Nigerian large construction projects. Also, this study is relevant because, so far as few study have focussed on risk management in large construction projects, this research contributes to the body of knowledge relating to the management of risk in large construction projects in Nigeria.

The findings of this study will provide practitioners; especially the participants of large construction projects with a clear understanding of key risks associated with large construction projects in Nigeria, the risk management strategies adopted in these projects and confirm the relevance of risk management in terms of the positive impact on project performance.

Additionally, the research findings will contribute to both the practice and research in risk management for the Nigerian construction industry and also provides valuable information for those international companies who intend to provide construction project management service to Nigeria. Furthermore, this research has the potential to provide a concise guide to the risk management process of highway projects in Nigeria and to draw on other infrastructure and major project areas.

The performance of highway construction projects in Nigeria in term of cost, time and quality is very poor. As a result, there is an increasingly rate of delay of construction project activities in Nigeria leading to cost and time overrun and consequently outright abandonment of projects (Sonuga et al., 2002; Aibinu and Jagboro, 2002; Aibinu and Odeyinka, 2006). There is still a lack of specific investigation on risk management in highway infrastructure construction projects in the context of Nigeria. Hence, this research focuses on Nigeria to develop a new risk management framework to improve the management of the identified key risks.

1.5 Research aim and objectives

The overall aim of this research is to develop a new risk management framework to improve the management of highway construction infrastructure projects in Nigeria.

To fulfil the above aim, the following specific objectives will be pursued:

- To gain the state-of-the-art knowledge in risk management involving civil engineering construction infrastructure projects
- To identify and analyse the important risks associated with highway infrastructure construction projects in Nigeria
- To investigate the risk management processes and techniques currently used in highway construction projects in Nigeria and evaluate their effectiveness
- To develop a new risk management framework to improve the management of the identified key risks

1.6 Research methods

The specific research methods employed for the research in order to fulfil the stated objectives of the research are illustrated in Figure 1-1. The research methods must be appropriate to fulfil the research objectives (Wing et al., 1998). Thus, the process adopted consists of four distinct stages:

- Stage 1 (literature review) satisfies the first research objective: A literature review refers to the process of finding and summarising the studies about a topic (Creswell, 2009). The literature sources for this study included, refereed academic journals, text books, conference papers, published PhD theses, government publications and other relevant documents, but with high priority given to refereed academic journals. This is because they are good representation of the extent of research achievements and they have been scrutinised by peer review (Sun and Meng, 2009). This review stage was used to establish the research gaps as well as the important risks associated with highway infrastructure construction projects and the project risk management processes and techniques.

- Stage 2 (fieldwork and analysis) meets the second and the third research objectives: The findings of the first stage lead to the development of stage two, in which the important risks associated with highway infrastructure construction

projects in Nigeria are identified and analysed and the risk management processes and techniques currently used in highway construction projects in Nigeria investigated and evaluated. To achieve this concurrent mixed method approach was deemed as a useful approach.

Mixing quantitative and qualitative techniques enables the researcher to balance the strengths and weaknesses of each approach and to substantiate the data obtained by various methods in order to validate the results of the research (Bryman, 2004). Therefore, a questionnaire survey was administered to highway construction infrastructure project practitioners in Nigeria through an email web link (LimeSurvey) and manual distribution. This was followed by conducting semi-structured interviews with Nigerian highway practitioners involved in four cases of on-going highway construction projects in Central Nigeria, South-East Nigeria and South-West Nigeria.

- Stage 3 (framework development) satisfies the fourth research objective: The findings from the literature reviews together with the questionnaire survey and case study findings in stage one and two led to the development of the newly highway project risk management framework in stage three.
- Stage 4 (framework evaluation), satisfies the fifth research objective. To evaluate the new risk management procedure for highway projects in Nigeria, semi-structured interviews were conducted with 16 highways experts involved in four distinct on-going highway infrastructure construction projects in Nigeria. The evaluation feedback showed that the developed framework is user-friendly, cost effective and suitable for developing countries as it does not involve complicated processes.

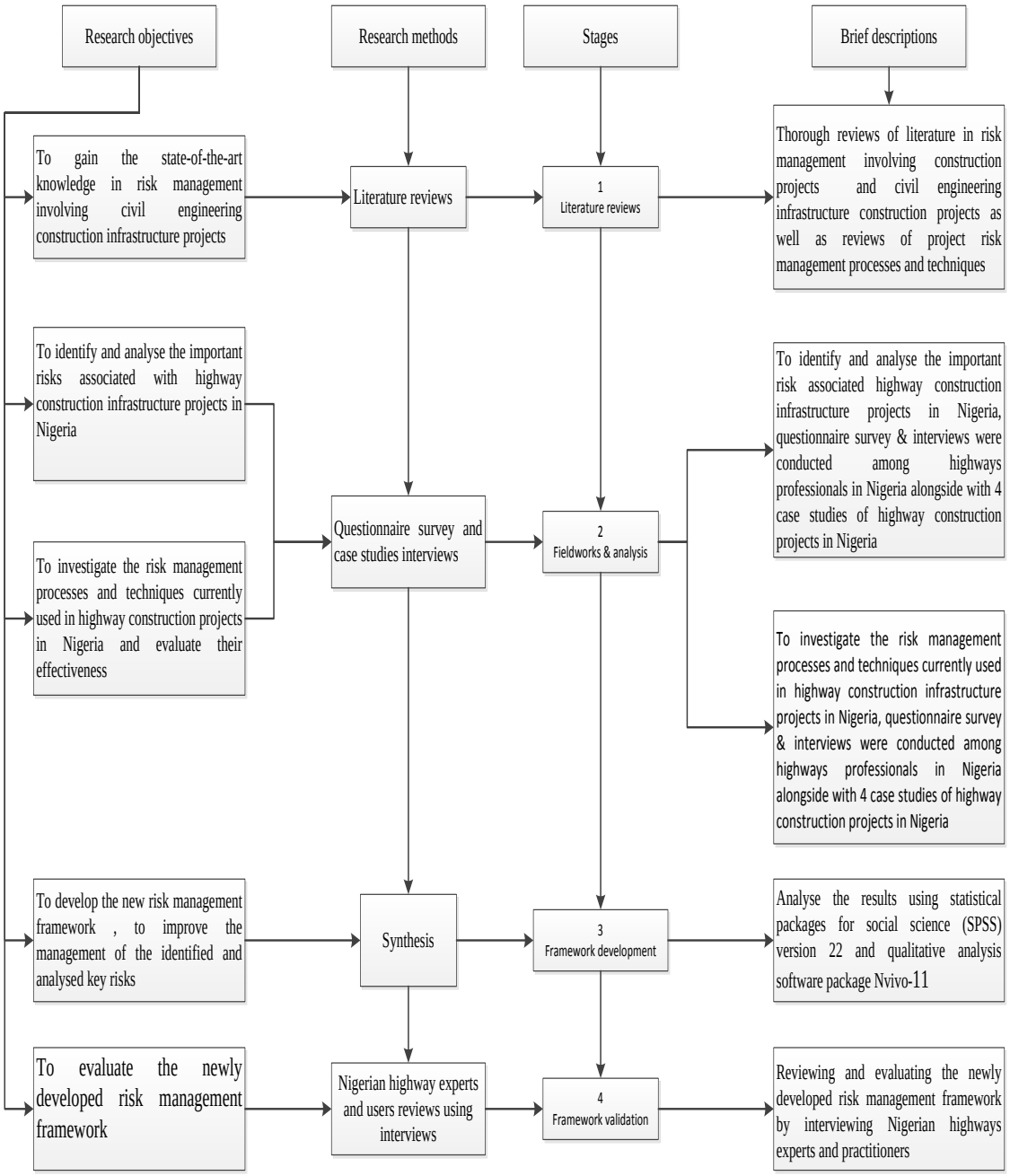

Figure 1- 1: Research objectives matched with research methods

1.7 Structure of the thesis

The entire thesis is presented in ten chapters. This section presents a brief overview of each of the chapters.

- Chapter 1 chapter has provided the background to the research, a statement of the problem, the research aim and objectives, an outline of the research objectives matched with the methods, and presented the structure of the research.
- Chapter 2 presents a literature review of the concepts of project risk and project risk management, risk management and the project lifecycle, risk management of major infrastructure construction projects in various countries and highway infrastructure construction projects in developing countries, including Nigeria, to establish the state-of-the-art knowledge in risk management involving civil engineering infrastructure construction projects. It concludes with a chapter summary and identifies the literature gap that provides the foundation for the problem statement.
- Chapter 3 presents a comprehensive review of risk management methodology, involving risk management process phases (risk management planning, identification, analysis, response and review and monitoring) and the tools and techniques relating to highway infrastructure construction projects. It reviews the findings regarding potential risks associated with highway infrastructure construction projects and proposes a classification for them that is the central theme of this research. It also provides a reflection of the preceding review followed by chapter summary and identification of the literature gap. Chapters two and three satisfy the first objective of the research and lay the foundation for the achievement of the remaining objectives.
- Chapter 4 presents an overview of the concepts that guide researchers, highlighting their associated methods and data collection tools; their strengths and weaknesses. The general research strategies are discussed followed by the discussion of the research strategy adopted for this research and the rationale for doing so.
- Chapter 5: Since the first part of data analysis is concerned with quantitative data analysis, this chapter presents the data analysis and the findings of the questionnaire survey. It presents the findings regarding the critical risk factors associated with highway infrastructure construction projects in Nigeria. It also

presents the risk management processes and techniques currently used to manage risks in the Nigerian highway construction projects, as well as examining their effectiveness. This chapter and chapter six satisfy the second and the third objectives of the research.

- Chapter 6 is a continuation of Chapter 5. It presents the results of factor analysis of highway project risks in Nigeria.
- Chapter 7 presents the second phase of the analysis, which is the data analysis of the case study interview findings from the four distinct on-going highway construction infrastructure projects in Nigeria. It also presents the findings regarding major risk factors affecting the performance of highway infrastructure construction projects in Nigeria and the risk management processes and techniques currently used in those projects to manage their risks, as well as their effectiveness, so as to validate the findings from the previous analysis. The chapter also presents the recommendations from the Nigerian highways practitioners on how to effectively manage the identified risks and concludes with summary of the research findings.
- Chapter 8 presents the development of the risk management framework for highway infrastructure construction projects in Nigeria to satisfy the fourth research objective. It outlines the principle and the rationale for the development of the framework.
- Chapter 9 presents the findings and discussion of the evaluation of the proposed highway project risk management framework by 16 Nigerian highway experts. It concludes with summary of the research findings.
- Chapter 10 presents a summary of the entire research findings in pursuit of the research aim and measures them against the specific research objectives. Conclusions and recommendations for implementation are discussed, followed by the limitations of the research and recommendations for future research

Chapter 2: Risk Management Philosophy

2.1 Introduction

This chapter begins by examining the concepts of risk and risk management. Various definitions of risk, both generally and in the context of construction project management, are examined. It also reviews previous studies concerning risk management and the project lifecycle, risk management of major infrastructure projects in various countries and finally highway infrastructure projects in general and particularly in relation to developing countries. This chapter and chapter 3 form the literature review for this study.

2.2 LITERATURE REVIEW

Literature review refers to the process of finding and summarising the studies about a topic (Creswell, 2009). The literature is an academic term meaning all the published work on a topic. A review is a piece of writing where you present/ compare/evaluate and discuss one or more published works. The literature sources for this studies includes, refereed academic journals, text books, conference papers, published PhD thesis, government publications and other relevant documents but with high priority on refereed academic journals. This is because, according to Sun and Meng (2009), they are good representation of the extent of research achievements; and they have been scrutinised by peer review. The literature searching started with the identification of key words. There was no time restriction as for the date of the publications.

The important research papers are identified and grouped using the following methods:

- Initially, the identified key words such as; ‘’risk’’, ‘’project risks and uncertainties’’, ‘’construction risk’’, ‘’project risk sources’’, ‘’infrastructure construction risk’’, ‘’infrastructure project risk‘’ highway project risk’’, ‘’project risk management’’, etc. were performed using several on-line databases including Science Direct, Emerald Fulltext, Taylor and Francis and Google Scholars in addition to the use of library resources.
- The initial key word search yielded many leading journals which are relevant to risk management in highway infrastructure construction projects. These journals includes but not limited to: ‘’International Journal of project management’’, ‘’Journal of Operation and Management’’, ‘’Journal of Financial Management

of Property and Construction'', ''Journal of Construction Engineering and Management'', ''Journal of Construction Management and Economics'', ''Engineering, Construction and Architectural Management'' and Journal of Professional issues in Engineering Education. Each of the articles identified in the journal were carefully reviewed before the decision for its selection.

- Reference lists of the paper identified in the above methods were also used to identify further relevant paper.

As a result of the above method, 156 articles have been found that had to be further reviewed for its inclusion in the current review. Literature mapping was used for the grouping of the most relevant articles. Further literature review is still on-going.

2.3 Project risks

A clear understanding of risk is important for effective project risk management. A number of definitions of risk are found in the literature. In the context of a project, risk can generally be defined as an uncertain event that affects project objectives either negatively or positively (PMI 2008; Caltrans, 2012). The APM (1997) defines risk 'as an uncertain event or set of circumstances that, should it occur, will have an effect on achieving the project objectives'. Events are said to be certain if their possibility of occurrence is 100% and uncertain if their possibility of occurrence is less than 100%. Both of the above definitions share the same view of risk except that it is emphasised in the later definition that a set of circumstances could result in risk to the project outcomes. This is particularly true in highway construction projects where there could be several interdependent parties and events contributing to the project. The uncertainty could be related to the likelihood that a future event may or may not occur and also the unknown degree of its impact on project objectives, should it occur. Therefore, a project risk could be characterised by its possibility of occurrence and its corresponding uncertain consequence on project objectives (e.g., cost, time, quality, scope). The impact of a risk can be measured as the possibility of a specific undesirable occurrence and its undesirable consequences. Mathematically, can be expressed as RI = P x C; Where: RI = Risk Impact; P = Possibility of Occurrence & C = Corresponding Consequences. Risk can be viewed as a threat or opportunity that is likely to adversely or favourably affect the achievement of the project objectives (Hillson, 2002; ICE, 2005). Threat in this definition refers to a risk with negative effects while opportunity refers to a risk with positive effects. According to BS6079-1(2000) guide to project

management part 1, project risk is characterised as the likelihood of negative occurrences that could affect the project adversely making it more difficult or even impossible to achieve its objectives. Caltrans (2015) view risk as 'the effect of uncertainty upon objectives'. A deviation from the expected, either positively or negatively, is an effect. There can be different categories of objectives which apply at various levels. From the researcher's point of view, risk can be defined as the negative or positive result of uncertainty on the performance of project objectives (e.g., time, cost, quality, environmental sustainability). However, this research focusses on the negative part or threat of risk on the performance of highway construction projects in Nigeria.

2.3.1 Risk and uncertainty

Literature reviews have shown that risk and uncertainty are frequently used together and sometimes considered to be interchangeable and synonymous (PMI. 2008; Jun et al., 2011; Caltrans, 2012). The concepts seem to be related and some publications tend not to distinguish between them. Considering the definitions of risk in the previous section, as defined by PM1 (2008) and Caltrans (2012), one could argue that risk and uncertainty can be used interchangeably and synonymously. Nevertheless, there is a clear distinction between them: although risk results from uncertainty, it can be argued that they are not synonymous (Lefley, 1997). Risk is measurable uncertainty while uncertainty is immeasurable risk (Olsson, 2008). This suggests that an uncertainty is to be considered as risk when measurable. Furthermore, risk involves a situation where the probability of the outcomes is known while uncertainty is a situation where the probability of the outcomes is not known (Olsson, 2008). Figure 2-1 further illustrates some of the differences between risk and uncertainty

2.3.2 Risk and issue

Risk and issues are two terms that have not been properly addressed. A project risk that has occurred can be seen as an issue. Just like risk and uncertainty, the two terms cannot be used interchangeably. The preceding sections made it clear that risk has probability associated with it but this is not so with issue. Think of issues as the problem at hand that the project team are facing that they need to do something about (Caltrans, 2012). Risk management can be considered as a proactive activity as opposed to issue management which can be considered as reactive

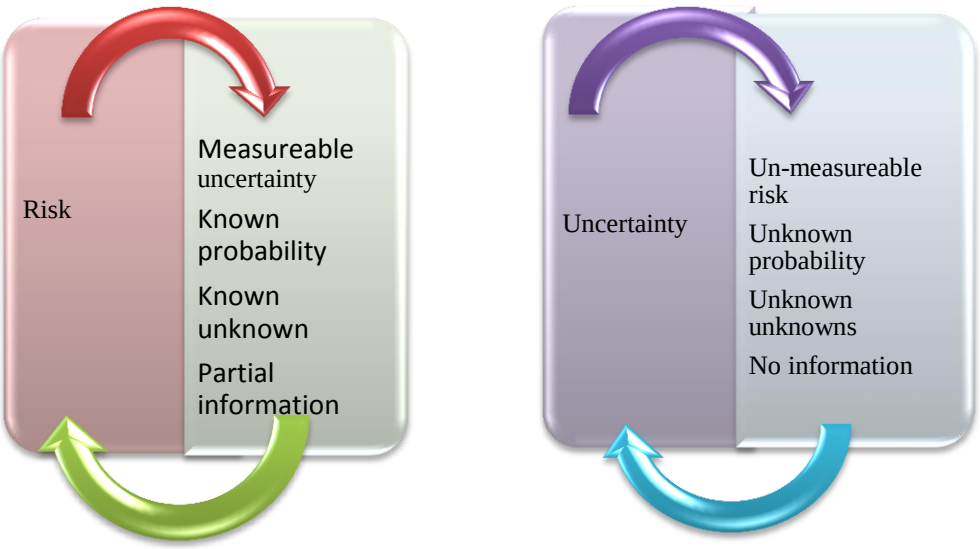

Figure 2- 1: Differences between risk and uncertainty

2.3.3 Sources of project risks

Project risks have their source from the uncertainty that is present to a different degree in all projects (PMI, 2008). Thus, risks are understood as one of the implications of uncertainty, in contrast to the traditional risk management approach which assumes risk is uncertainty. While project size can be one of the major causes of risk, other factors carrying risk along with them are complexity, speed of construction, location of the projects, technology being used and familiarity with the work (Dey and Ogunlana, 2004; Jun et al., 2011). Furthermore, risk in a project can be as a result of lack of team expertise and experience on a particular project, the possibility of occurrence of some set of circumstances and volatility of market conditions. The current development in the construction industry is toward increasing project size and complexity, both of which result in greater level of risk and uncertainty (Abdelgawad and Fayek, 2010). The science and engineering involved in many major projects become increasingly complex, resulting in higher risks. However, the need to identify project uncertainties, estimate their impact, analyse their interactions, and control them within a risk management structure has only been realized in recent years, mainly within the defence, construction and oil industries (Dey and Ogunlana, 2004). Compared to other businesses, the construction industry is exposed to more risks and uncertainties. The effect of this is poor project performance (e.g., cost and time overrun and poor quality work which further results in outright abandonment of projects, in some cases, for

example, the Skytrain Project in Thailand; the Very Fast Train (VFT) Project in Australia and the Akkyku Nuclear Power Plant in Turkey (Yeo and Tiong, 2000).

2.4 Project risk management

Risk management in the construction project management context is the extensive and well-organized way of planning, identifying, analysing, and reacting to risks that may positively or negatively affect project success. The purpose of risk management is to recognize uncertain situations that might jeopardize the success of construction projects and develop strategies to decrease the possibility of their occurrences. Alarcón et al. (2010) define risk management as the art and science of anticipating and planning for future uncertain events. Its objective according to my review is to understand and mitigate or control risks. Understanding the risk inherent in each of the phases of a construction project is important to improve project performance. Risk management is an integral part of project management (Olsson, 2008; Osipova and Eriksson, 2013). To support this view, it should be noted that the PMI (2004 & 2008) has included risk management as one of the nine Knowledge Areas in project management and described it as the process concerned with conducting risk management planning, identification, analysis, responses and monitoring and control on projects. The underlying concept of risk management is to manage risk effectively (Lyons and Skitmore, 2004). Risk management is most effective when first implemented at the early phase of the lifecycle of a project and then extended to the remaining phases of the project's life cycle (Caltrans, 2007; Choudhry et al., 2014).

2.5 Risk management and the project lifecycle

The project life cycle includes all the phases of project delivery from initiation to the completion of a project to achieve its objectives. According to Grimaldi et al. (2012) it is a natural setting for determining specific risk management methodologies. Various terminologies for and explanations of what these phases (stages) consist of exist in the literature, as shown in the example in Table 2-1.

This research recognises four general kinds of phases that can be associated with the lifecycle of highway infrastructure construction projects, which are the feasibility, design, construction and operation phases. These falls into two main phases: the strategic (definition) and tactical (delivery) phases.

Table 2- 1: Examples of project management lifecycle definitions

Project lifecycle framework	Representative literature
Conceptualization, Planning, Execution & Termination	(Lyons & Skitmore, 2004; PMI, 2008; Grimaldi et al., 2012)
Feasibility Design, Construction & Operation	(Zou et al., 2007)
Planning, Design, Construction Trial operation and Operation & maintenance	(Qin & Jing, 2016)
Pre-planning (conceptual), Design/pre-construction, Construction and Operation & maintenance	(Hastak &Baim, 2001)
Conception, feasibility, implementation, operation & termination	(BS6079-1, 2000)

The level of available information about the project and its environment (e.g. stakeholders, scope, time, and cost) varies through the successive phases of the projects. Consequently, as the amount of information increases, uncertainty will be reduced, and risk will also be reduced. Therefore, there are more risks at the commencement of a project, while they reduce as the project approaches its termination phase (Grimaldi et al., 2012). However, it has been argued that this will not always be the case in a complex project within a changing environment, where uncertainty will not necessarily diminish over time (Jafari, 2001). Grimaldi et al. (2012) suggest that the greatest opportunity for risk reduction lies in the early project stages. Approaching risks issues effectively and efficiently in the early phase is highly likely to provide high cost benefit; hence, it is recommended from inception, through successive project phases (Mills, 2001). Additionally, it has been recommended that the risk management processes should be directed toward monitoring the changes as well as the new risks emerging in the execution (Construction) phase and adopting the suitable strategies to mitigate them.

Numerous risks exist throughout the life cycle or phases of construction projects and they differ according to the project type, the contract involved and the procurement route. Beginning from feasibility phase through to the operational phase, risk involved in major infrastructure project can have direct effect on the project's schedule, cost and overall performance, (Choudhry et al., 2014). Managing risks during the construction phase of a highway project could be as important, if not more important and complex,

than in the other phases. Risk management seem to have been given more prominence in the tactical phase of the construction project compared to the strategic phase. The reason for this is that in the strategic phase, project risk is not characterised by many noticeable risk events that could jeopardise project performance. Additionally, during the tactical phase e.g., the construction phase, the design is supposed to be fixed; thus, the project advancement is no longer tied to creating a deliverable timescale but on adhering to it; and financial risk is no longer an issue of pricing but focused on cost control (Zou et al., 2007). Certain risks could be transferred, retained or mitigated during the feasibility, design, tender or contract negotiation phases (Eskesen et al., 2004; Zou et al., 2007). During the construction phase, the likelihood of risk transfers is limited; hence, the contractors, clients and consultants are drawn to reduce the consequences of the occurrences of the risks (Eskesen et al., 2004). During each phase of the project life cycle, the cost of attending to the risk could increase either immediately or during the successive phases of the project (Hastak & Baim, 2001). Thus, adopting a phase by phase approach to project risk management is particularly important when projects are executed in phases, giving room for a formal review at the end of each of the phases.

2.6 Risk management of major infrastructure projects

Ng and Loosemore (2007) identified two broad classifications of civil engineering infrastructure projects, which are economic infrastructure projects (e.g. bridges, drainage systems, sewage treatment plants, telecommunications networks & road, rail & air transport facilities) and social (e.g. education, health, tourism & education facilities) infrastructure projects (Figure 2-2). The emphasis of this research study is on highway infrastructure construction projects. All infrastructure projects are exposed to high levels of community involvement and accountability, as well as political pressure that could interfere with the effective funding, management and procurement of the projects (Ng and Loosemore, 2007). Such projects have long-term durations and naturally entail significant technical, legal, political and economic risks. Furthermore, they share some common risk management elements; these include: multi-layered relationships; cost, time and safety; procurement and contract; environmental and social concerns; construction innovation and economic return (Guo et al., 2014).

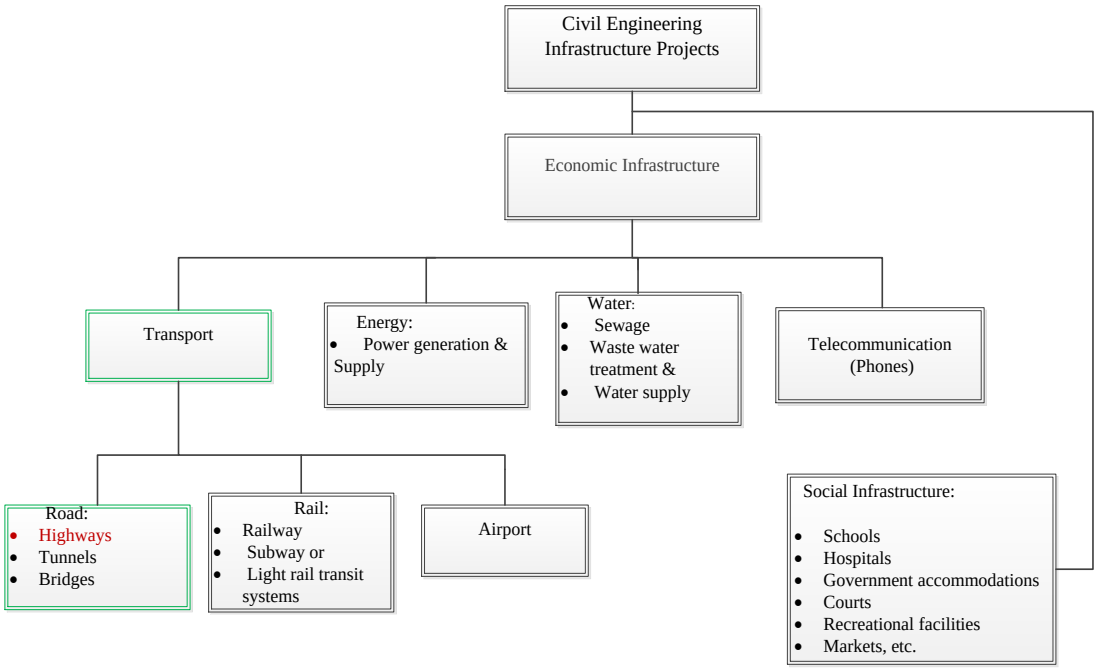

Figure 2- 2: Classification of Civil Engineering Infrastructure projects (Source: Ng and Loosemore, 2007).

Various risk factors are associated with large public infrastructure projects such as highway infrastructure construction projects, and the performance of such projects depends on the efficient and effective management of the critical risk factors. Compared to small and medium-sized construction projects, large infrastructure construction projects involve more intricate organizational structures to deal with a series of risk management elements. Achievement of time, cost and quality performance of large scale construction projects is always uncertain, due to their uniqueness (Dey, 2012).

Hence, comprehensive risk assessment is fundamental to understanding and improving the risks of major infrastructure projects (Wang et al., 2016). To efficiently and effectively manage these risks in major infrastructure projects, various approaches have been adopted in the literature, as summarised in Table 2-2. As can be seen in the table, there have been a considerable number of studies in various countries identifying the risks that affect the performance of large infrastructure projects. According to these studies, each country is exposed to different levels of risk, although they share some common similarities, as previously stated. It is also noted that most of the risks identified occurred during the construction phase of the infrastructure project. Across the different studies complex mathematical models and frameworks are proposed to

address the risks affecting the performance of major infrastructure projects in different countries. The application or practicability of such models or frameworks depends on the project risk management capabilities of an organisation. This again varies across different geographical locations. Risk management is recognised as an essential and integral part of project management in virtually all construction projects (Choudhry et al., 2014).

Table 2- 2: Risk management of major infrastructure projects in various countries

Infrastructure project type	Location	Representative literature	Main findings
Cross-sea route	China	Wang et al. (2016).	▪ Developed a major infrastructure risk assessment framework (MIRAF) based on an adapted Analytic Hierarchy Process (AHP) risk assessment model, and applies it to a cross-sea route project that is expected to connect Guangdong Province and Hainan Island. ▪ Key risk factors identified during the implementation of the tunnel scheme are damage to commercial interests of local fishermen, damage to habitat for rare and endangered animals, financial crisis and sea storm surge.
Highway construction project	UAE	El-Sayegh and Mansour (2015)	▪ Identified the risks associated with highway construction projects in the United Arab Emirates (UAE). ▪ Using the relative importance index (RII), the risk priority is calculated which indicated that the most significant risks were inefficient planning, unexpected ground utilities, quality and integrity of design, delays in approvals, and delays in expropriation. ▪ Based on their finding, proposed risk allocation framework.
Bridge construction	Pakistan	Choudhry et al. (2014)	▪ Grouped risk into 7 main categories: financial risks, external risks, design risks, management risks, construction risks, contractual risks, and health and safety risks. ▪ Identified and analysed risks affecting bridge construction project performance through interviews conducted with engineers and managers involved with various bridge projects. ▪ Top 5 highest-ranked risk factors were unavailability of funds; financial failure of contractor, poor site management and supervision, inadequate site investigation affecting the performance of bridge construction. ▪ Provide risk analysis guideline for Bridge construction in Pakistan's culture.
Seaport	UK	John et al. (2014)	▪ Developed a novel fuzzy risk assessment approach to facilitating the treatment of uncertainties in seaport operations and to optimise its performance effectiveness in a systematic manner using a fuzzy analytical hierarchy process, an evidential reasoning (ER) approach, fuzzy set theory and expected utility.

Yi-Wan Railway & Northern Gateway Toll Road Construction projects	China & New Zealand respectively	Guo et al. (2014)	▪ Investigated how different project governance structures affect the management of risks. ▪ Used desktop review and interviews with stakeholder organizations in two major infrastructure projects (the Yi-wan Railway Construction Project in China and the Northern Gateway Toll Road (NGTR) Project in New Zealand). ▪ Key risk management element of Yi- Wan Railway construction includes; safety, environmental conservation, investment viability and schedule while the key risk management element associated with Gateway Toll Road construction includes; time &quality, cost, availability of labour, environmental & social measures and collaborative mechanism. ▪ Comparative analysis result indicated that project governance provides a structured mechanism to identify and address risks as they occur. ▪ Assert that there is still a lack of in-depth case studies (including studies of processes and studies of real-time projects) that can increase the understanding about risk management in large infrastructure projects.
Highway	USA	Tran and Molenaar (2013)	▪ Investigated the relationship between highway design and construction delivery selection using exploratory factor analysis. ▪ Key risk areas identified to have the most influence on the delivery selection were: scope, third-party & complexity; construction, utility& right-of-way; level of design & contract, management and regulation & railroad risks.
Highway projects	Iran	Mousavi et al. (2011)	▪ Grouped highway project risks into engineering, procurement, construction and management. ▪ Developed a statistical approach for analysing the impact of risks using a non-parametric jack-knife technique. ▪ Highway project data and experts' comments in developing countries are few and limited.
Bridge construction	Iran	Hashemi et al. (2011)	▪ Proposed a new hybrid approach by using a nonparametric resampling technique (Bootstrap techniques) and interval computations for risk analysis, in particular, for bridge construction projects. ▪ Key risks identified include: change in regulations; construction permission issues; delayed payment on contract and extras; design changes; insufficient technology; pollutions and safety rules; poor relationship among parties; scope change; shortage of labour, material, and equipment and site management staffing.
Tehran–Chalus Toll Road	Iran	Heravi and Hajihosseini (2011)	▪ Provided a case study of the Tehran–Chalus Toll Road project, one of the largest highway projects in Iran. ▪ Key risk group identified includes: political, financial, market, legal, operation & maintenance; organisation & coordination; and force majeure risks. ▪ Provided recommendation on how these risks can be managed.
PPP Expressway	China	Li et al. (2011)	▪ Developed a fuzzy analytical hierarchy process (AHP) as risk assessment technique to simulate the

			vagueness of human judgement and to improve the assessment accuracy to rank the risks. ▪ Key top 5 risks identified includes: planning deficiency, low project residual value (after 30 years of operation), lack of qualified bidders, design deficiency, and long project approval time.
16 Public PPP Projects	China	Ke et al. (2010)	▪ Developed risk allocation framework based on 16 cases of public PPP projects in China (e.g. Beijing Jingtong Expressway; Shanghai Yan'an Road. (E) Tunnel; Hangzhou Bay Bridge, etc.) ▪ Key risks were grouped into: Political; construction; operation; legal, market, economic & natural.
Highway construction projects	China	Zayed et al. (2008)	▪ Highway construction projects are exposed to high risk because they are capital intensive and involve complicated site conditions. ▪ Sources of these risks includes: political, economic, cultural, market, and technical risks. ▪ These risks can be minimised or transferred from one project stakeholder to another but cannot be eliminated. ▪ Identified two areas of risks associated with highway projects as Macro (company level) and Micro (project level). ▪ Developed risk index model using Analytic Hierarchy Process (AHP) to assess the level of risk associated with the highway project in the bidding phase in order to take preventive actions based upon 4 Chinese case studies. ▪ The findings reveal most critical risks as political financial, technology and resource. ▪ The author suggested that risks and uncertainty associated with highway construction projects have not receive sufficient attention from researchers world-wide.
BOT Toll Road project	USA	Chiara and Garvin (2008)	▪ Developed a new family of Markovian processes, the Martingale variance model and the general variance model, as an alternative modelling tool for BOT toll road projects risk variables with two-year construction period.
Highway projects	Brazil	Filippo et al. (2007)	▪ Developed a procedure for risk ranking environmentally valid highway restoration by priority, using a Fuzzy Multi-Criteria Model that supports decisions on which road segments require these works and services. ▪ The major risk areas considered are risk of accidents, economic and strategic importance, environmental degradation and the risk of erosion and landslides along the highway.
The New Southern Railway	Australia	Ng and Loosemore (2007)	▪ Presented a case study of the controversial $920 million New Southern Railway project in Sydney, Australia and then provided with a series of recommendations (Risk Allocation Framework) to better manage risks in such projects. ▪ Key risks identified include: credit, construction, revenue structure, operating, financial and legal structure risks.
Hong Kong PPP projects (e.g.	Hong Kong	Shen et al. (2006)	▪ Examined the major risks in implementing public sector works, and the ways that the application of public private partnership (PPP) can help to manage risks in project delivery.

Hong Kong Disneyland)			▪ Grouped risk in public infrastructure projects into: project, government, client, design, contractor, consultant & market related risks. ▪ Using Hong Kong Disneyland (KDLD) as a case studies, developed risk allocation framework that demonstrates how various major risks in committing to a PPP project are allocated and shared effectively between public and private partners.
PPP Public Infrastructure projects	UK	Bing et al. (2005)	▪ Conducted a questionnaire survey to explore risk allocation preferences in PPP public infrastructure projects (e.g. hospital, transportation, power & energy, housing &office). ▪ Grouped risks into: Macro-level, Meso-level and Micro-level risks ▪ Developed risk allocation frameworks to be used in the early stages of project development.
Highway projects	Taiwan	Wang and Chou (2003)	▪ Conducted multiple-case studies using a systematic analytical procedure to identify risks in highway projects, to recognize risk allocation through contract clauses, and to analyse the influence of risk allocation on the contractor's risk handling strategies ▪ Main risk areas identified include: political & economic; natural environment; third party; owner, design consultant, & supervisor; contractor; labour; subcontractor; material and equipment. ▪ Stated that research on risk handling strategies in construction projects was scarce and that it was seldom discussed how to employ techniques and methods to control risks.

2.6.1 Risk management in highway construction projects

Major public infrastructure projects have substantial impacts on the economy, society, environment, politics, security, and safety (Wang et al., 2016). Highway infrastructures are valuable assets of any nation, globally. They can be described in terms of public goods and services in which government policy plays a significant role to influence the effect of the project on economic development and social needs. They are the footing for social and economic development, the wellbeing of communities and providing access for business. Therefore, investments in infrastructure are essential, especially in developing countries.

To undertake a highway construction project is a capital intensive endeavour; hence careful planning and substantial amounts of time and resources are required to achieve its performance objectives. The execution of such projects is very often either through the construction of new roads, bridges culverts or periodic maintenances of the existing ones. The cost of highway infrastructure construction project is very enormous and the construction phase naturally takes the lion share of this cost consisting of each of the element of the infrastructure such as roads, bridges or flyovers. (Heralova et al., 2014)

The recent global economic meltdown poses a major challenge to highway construction project authorities to make judicious use of limited resources in delivering an acceptable level of highway services to the populace. The limited availability of resources, inadequate funding and shortage of skills implies a pressing need for a more effective and efficient way of managing highway construction projects. As pointed out earlier, the risks associated with highway construction projects are higher compared to traditional projects, since they are capital intensive, more complex and highly dependent on economic, societal and political challenges (Zayed et al., 2008; Ahmadi et al., 2017). The success of construction projects, among other things, depends on how well the risks that are associated with them are managed. What are these risks and their sources? Table 2-3 is a summary of checklists of highway infrastructure project risks, sourced from relevant civil engineering infrastructure and project risk management literature, which are classified into two main groups and subsequent sub-groupings. The history of project failure globally is a proof that risks are not properly dealt with**.** Additionally, Tar and Carr (2000) attributed the reason for poor project performance to lack of formalized risk management procedures. Hence, one can infer that risk management is all about making decisions that improve project performance to achieve project

objectives. This implies that risk management is an effective decision tool that can improve the performance of highway construction projects.

Table 2-3: Highway construction infrastructure project risks from different studies and proposed classifications

Risk group	Risk factor level	Risk factor sub-level	Representative studies																
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
External	Political	Unstable government			*		*	*	*	*	*	*	*	*			*	*	*
		Project being cancelled due to change in ruling party								*	*						*	*	*
		Political interference					*	*		*	*								*
		Expropriation /Nationalisation						*	*	*	*			*					*
	Corruption	Government officials demand bribe /unjust reward	*					*			*		*	*					
	Economic	Exchange rate fluctuation	*	*	*	*				*	*		*			*	*		
		Inflation/interest rate fluctuation	*				*	*	*	*	*	*	*		*	*	*	*	*
	Social/cultural	Level of public opposition to projects						*	*		*		*			*			
		Poor relationship with community	*	*	*	*					*		*	*		*			
	Land	Landowner unwilling to sell										*	*					*	*
		Land acquisition and compensation problems							*	*		*						*	
	Natural	Inclement weather	*	*	*			*	*	*		*	*	*	*		*	*	
		Adverse ground conditions	*	*	*	*				*		*	*	*		*	*	*	
	Force majeure	Terrorist attack	*								*			*		*		*	*
		Flood			*					*	*			*		*	*	*	*
	Legal	Lack of legal regulatory framework					*				*	*	*			*		*	
		Weak regulatory & monitoring regime					*				*		*			*			
	Technology	Unavailability of special equipment	*	*			*			*		*							
		Failure of major constr. equipment & Unavailability of spare parts					*			*		*							
Internal	Financial	Project funding challenge	*	*		*	*	*	*	*	*	*	*			*		*	
	Construction	Construction time delay		*	*		*	*	*	*		*				*			*
		Construction cost overrun			*		*	*	*	*	*						*	*	*
	Design	Defective design, error and rework	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	

	Availability of design details	*****	*****			*****						*****	*****									
Procurement	Inappropriate procurement methods	*		*		*						*	*	*		*			*			
Operational	High maintenance cost						*	*	*											*	*	
Management	Poor communication within different parties					*	*			*			*									
	Lack of quality control and monitoring	*	*	*		*		*		*	*	*			*			*			*	
	Subcontractors' incompetence	*		*	*					*	*					*						
	Poor competence of workers			*							*											
Resource	Shortage of experts in highways	*	*		*	*			*		*	*	*	*		*			*			
	Shortage of skilled workers	*	*		*	*					*	*	*	*		*			*			
	Shortage/unavailability of materials	*	*		*	*	*		*		*	*	*	*		*			*			
Third party	Lack of commitment between parties	*	*		*	*		*			*						*	*				
Relationship	Lack of joint risk management mechanism by parties		*		*	*														*	*	

(*Inclusive of specific risk factors in representative literatures were: A= El-Sayegh, 2008; B = Zayed et al., 2008; C = Wang and Chou, 2003; D = Tang et al., 2007; E = Shen et al., 2006; F = Hwang et al., 2013; G = Bing et al., 2005; H = Ke et al., 2010; I = Wang et al., 2004; J = Choudhry et al., 2014; K = Mousavi et al., 2011; L = El-Sayegh &Mansour, 2015; M = Alarcón et al., 2010; N = Ghosh and Jintanapakanont, 2004; O = Chan et al., 2011; P = Heravi et al., 2011; Q = Ng and Loosemore, 2007))

2.6.2 Highway project risk management in developing countries

Construction industries in developing countries are susceptible to more fundamental, serious, and complex drawbacks and generally much more demanding than those facing their counterpart elsewhere (Ofori, 1993). Although there have been considerable efforts in large infrastructure project risk management research, there is still a lack of specific investigation on risk management in highway infrastructure construction projects in the context of Nigeria. Although the literature review shows that risk management in highway infrastructure projects has been given substantial attention in recent years, It also reveals that risk and uncertainty regarding highway projects in the developing countries, particularly in Sub-Saharan Africa (e.g. Nigeria), has been under-researched compared to countries like the USA, UK, Germany or Australia. Even compared to countries in the Asian region (e.g. China, Iran, and Pakistan), the literature review has found that Sub-Saharan Africa has been under represented in research regarding highway construction project risk management (see Table 2-2). Ahmadi et al. (2017) asserted that one of the main issues with highway construction project risk management in developing countries is lack of a documented inventory of the relevant data for completed projects. Additionally, there is dearth of empirical studies directed to identifying risks in real life highway infrastructure construction projects in the context of developing countries (Dang et al, 2017). Hence, filling this knowledge gap could contribute to improving the sum of global knowledge in this field.

Management of a highway construction project is a critical challenge facing authorities in both developed and developing countries, particularly in Nigeria. Both past and recent research acknowledges that the risks and uncertainty associated with highway construction projects have not receive sufficient attention from researchers world-wide (Zayed et al., 2008; Mousavi et al., 2011; Guo et al., 2014). To improve this understanding, this research is undertaken to bridge the gap in this knowledge area. Although there are some similarities in the risks that affect the performance of construction projects world-wide, they are also affected by country-specific conditions (Oluwale and Sun, 2010). Accordingly, the political, economic, legislative, social and cultural differences in diverse countries account for differing levels of risk in highway construction projects. The many instances of poor performance of highway construction projects in developing countries compared to those in developed countries

are a result lack of understanding and application of risk management. In fact, El-Sayegh & Mansour (2015) reported that the lack of a risk management system in place is responsible for many infrastructure project failures in developing countries. The literature review further reveals that risk management processes, including planning, tools, documentation and communication, are less focused on than any other areas of highway construction project management (Mousavi et al., 2011). Generally, risk management is not seen as a priority for delivery of construction projects in developing countries (Choudhry and Iqbal, 2013; Reza et al., 2016). Hence, little evidence and information exists for its application in construction projects from developing countries. Understanding of risk and its management processes will enable responsible parties to take proactive steps in reducing their negative consequences on the project objectives through efficient and effective management.

2.7 Chapter Summary and literature gap

A review of risk and risk management, particularly in the context of major infrastructure projects in different countries and highway infrastructure projects in developing countries and in Nigeria, has been presented in this chapter. Ensuring effective delivery of highway construction projects to cost, schedule and performance requirements and take into account environmental sustainability, requires identifying and managing the associated risks. Beginning from the feasibility phase through to the operational phase, risks involved in major infrastructure projects can have direct effect on the project schedule, cost and overall performance. Highway infrastructure construction projects are the foundation for social and economic development, ensuring the wellbeing of the communities and providing access for business. Therefore, investments in highway infrastructure projects are essential, especially in developing countries. The many instances of poor highway construction project performance in developing countries compared to that in developed countries are attributed to a lack of understanding and application of risk management (Mousavi et al., 2011; El-Sayegh & Mansour 2015; Dang et al, 2017). Review of the literature review has shown that the essence of project management is risk management. Such a perspective regards project risk management as a fundamental approach to increasing the possibility of project success. Unfortunately, the project management methodology that has been adopted in most companies does not readily accommodate the increasing requirements for risk management (Chouldhry and Iqbal, 2013) and as a result many projects are not set up to

manage risk. This is usually the case in most developing countries, particularly, Nigeria. The extensive review in this chapter have identified checklists of highway infrastructure project risks (sourced from relevant civil engineering infrastructure and project risk management studies) and classified them into two main groups and subsequent sub-groupings, as shown in Table 2-3. To achieve the objectives of this research, there is need to ascertain which of these risk factors are relevant to the Nigerian highway construction projects.

The performance of highway construction projects in Nigeria in term of cost, time and quality is very poor. As a result, there is an increasingly rate of delay of construction project activities in Nigeria leading to cost and time overrun and consequently outright abandonment of projects (Sonuga et al., 2002; Aibinu and Jagboro, 2002; Aibinu and Odeyinka, 2006). There is still a lack of specific investigation on risk management in highway infrastructure construction projects in the context of Nigeria. Hence, this research focuses on Nigeria to develop a new risk management framework to improve the management of the identified key risks.

The chapter has also identified the following gaps:

- Although there have been considerable efforts in large infrastructure project risk management research, there is still a lack of specific investigation on risk management in highway infrastructure construction projects in the context of Nigeria.
- Risk and uncertainty of highway projects in the developing countries, particularly in Sub-Saharan Africa, (e.g. Nigeria) has been under-researched compared to large developed
- There is little data and expert feedback on highway projects in developing countries.
- Risk management processes (planning, tools, documentation, and communication) are less focused on by researchers than any other areas of highway construction project management
- Hence, little evidence and information exists for its application in construction projects from developing countries perspective.
- Therefore, the demand for a more efficient and effective approach to improve the management of highway projects in developing countries motivates this research.

The next chapter presents a review of risk management methodologies in highway construction projects.

Chapter 3: Risk Management Methodology

3.1 Introduction

To effectively and efficiently manage risk associated with highway infrastructure construction projects in developing countries, a thorough and systematic methodology and, more importantly, knowledge and experience is required. In continuation of chapter two, a review of the risk management processes, including risk management planning, risk identification/classification, analysis, response planning, monitoring and reviewing, is conducted in this chapter.

3.2 Risk management process phases

The review of the literature in the previous chapter highlighted lack of knowledge and systematic application of risk management practices by both owners and contractors as one of the reasons for many highway construction projects' failures or poor performance. It has been noted that risk management in construction project management, in developing countries in particular, is often dealt with using contingency plans which are not determined based on comprehensive identification and analysis of the risks that can affect a particular project (Mok et al., 1997; Serpella et al., 2014). A proper risk management process offers a cogent and consistent framework for identifying and understanding possible risk factors, assessing consequences and their uncertainties, and evaluating and choosing best courses of action necessary to handle the identified risks in order to accomplish the desired project objectives. According to Caltrans (2012) project risk management is basically about providing answers to a few basic questions, as shown in Figure 3-1, which illustrates what the risk management process is all about.

The questions in Figure 3-1 specify the main issues of the project risk management process, which is fundamentally seen as the process associated with performing the following phases: risk management planning, risk identification, risk analysis, monitoring and review (which will be discussed in detail in the following sections). Details of the risk management process could vary depending on the project, but there are three main components: identification, analysis and response (Caltrans, 2012). There are different views of what these entail, held by different researchers, as shown in Table 3-1. As seen in the table, there are several commonly accepted approaches to risk

management that have been proposed. In comparing these approaches, however, inconsistencies in terminology and intersecting actions are frequently found, since they emerge from different views and aim to fulfil different needs. Drawn from these reviews, risk management processes can be summarised as shown in Figure 3-2

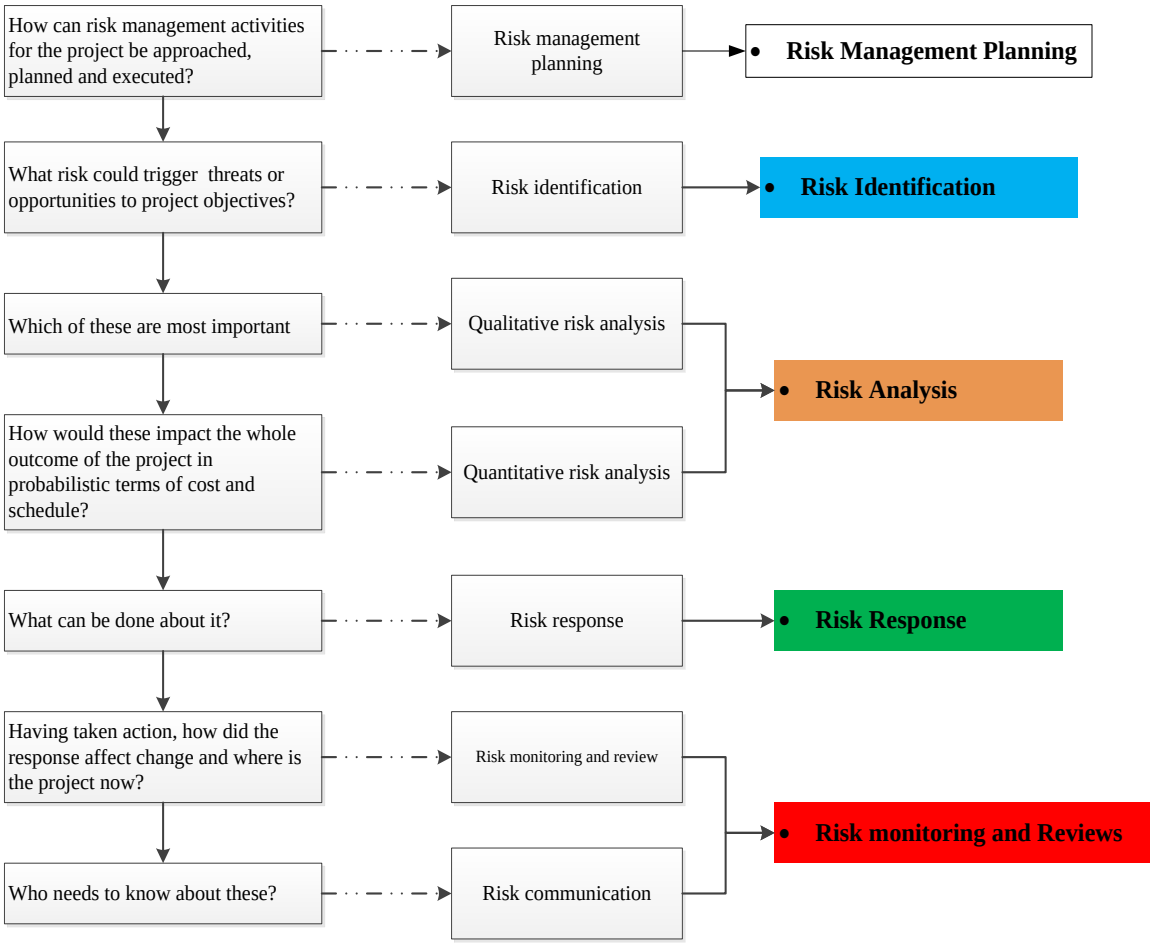

Figure 3- 1: Project risk management process, what is it all about? (Source: Caltrans, 2012)

Table 3- 1: Overview of risk management processes

Major steps in project risk management	**Planning**	**Identification**	**Analysis**	**Response**	**Risk Monitoring & Reviews**
Risk management process: Hwang et al. (2014)	Risk management planning	Risk identification	Qualitative & quantitative risk analysis	Risk response planning	Monitoring & control
Risk management process: Osipova & Eriksson (2013)	Risk management planning	Risk identification	Assessment (qualitative and quantitative) of identified risk	Action planning to handle risks	
Risk management framework: Tar and Carr (2000)		Risk identification	Risk assessment Risk analysis	Risk handling	Monitoring
systematic risk management process Zou et al. (2007)		Risk identification &classification	Risk analysis	Risk response (retention, reduction, transfer & avoidance)	
Risk management process: Banaittiene et al. (2011)		Risk identification	Risk assessment	Risk mitigation	Monitoring
Risk management process Fisher & Robson (2006)		Risk identification	Risk assessment	Monitoring & control Response (avoidance, reduction, transfer and retention)	
APM-ARAM risk management process: Chapman (1997)	Focus Define	Identify Structure	Estimate Evaluate	Plan Ownership Manage	
Risk management process: Zayed et al. (2008) &Olsson (2007)		Risk identification	Risk assessment	Risk mitigation	
Systematic risk management process: Wang et al. (2004)		Risk identification	Risk analysis Risk evaluation	Risk response	

Risk management process: Zwikael & Sadeh (2007)	Risk management planning	Risk identification	Qualitative & quantitative risk analysis	Risk response plan Risk monitoring and control	
Risk management process: Hillson (2002)	Risk management planning	Risk identification	Qualitative & Quantitative risk analysis	Risk response planning-(avoid, transfer, mitigate & accept)	Monitoring and control
Systematic risk management process: Zhi (1995)	Risk classification	Risk identification	Risk assessment	Risk response	
Risk management process: Forbes et al. (2008)		Risk identification	Risk analysis Estimation & evaluation	Risk response	Monitoring
Project risk management process: Chapman (2001)	Knowledge acquisition-Strategic brief, feasibility study, cost plan & Master programme	Risk identification	Qualitative & quantitative risk analysis	Risk response planning (remove, reduce, retain & transfer) Resourcing & Ownership (resource allocation, responsibility assignment & Risk monitoring & reporting implementation Risk controlling	Monitoring & reporting
Risk management methodology: Patterson & Neailey (2002)		Risk identification	Risk assessment Risk analysis	Risk reduction/ & or mitigation	Monitoring
Risk management process: Afila and Smith (2007)		Risk identification and classification	risk analysis	risk response (retention, reduction, transfer & avoid)	
Risk management process: Zou et al. (2009)		Risk identification	Risk analysis	Risk response & communication,	Monitoring, review & learning
Risk management process: Zeng et al. (2007)		Risk identification	Risk assessment	Risk response	Monitoring and reviewing

OGC-management of risk: Raftery (1994)	Context	Risk identification	Assess-estimate Assess-evaluate	Plan Implement Communicate	
Risk management process: Alhawari et al.(2012)		Risk identification	Risk analysis	Risk response planning Risk education	Monitoring
Caltrans (2012)	Risk management planning	Risk identification	Qualitative & Quantitative analysis	Threat response (avoid, transfer, mitigate & accept) Opportunity response (exploit, share, enhance & accept)	Monitoring
PMI (2008)	Risk management planning	Risk identification	Qualitative & Quantitative risk analysis	Threat response (avoid, transfer, mitigate & accept) Opportunity response (exploit, share, enhance & accept	Monitoring & control

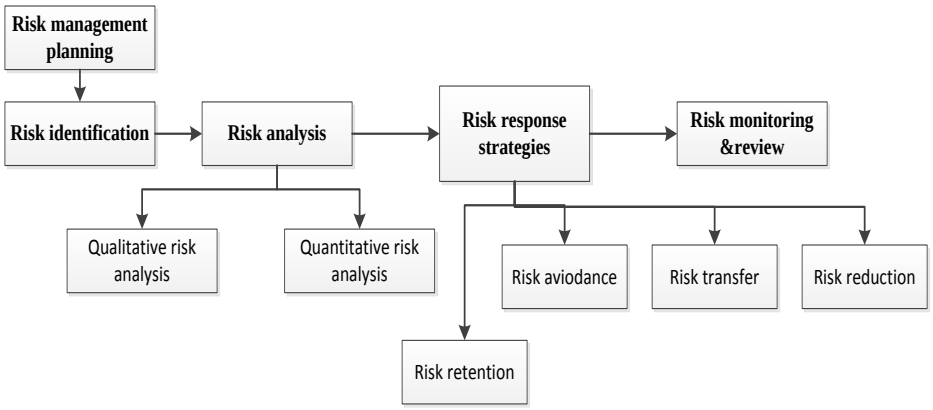

Figure 3- 2: Schematic framework of general risk management process

3.3 Risk management planning Phase

Just like risk management, risk management planning is a fundamental component of project management planning and it lays out how risk management will be carried out and executed throughout the project. It is the project team's responsibility, under the leadership of the project manager, to define and agree on the process to be followed at the kick-off as part of the whole project management plan. As shown in Table 3-1, many risk management frameworks (e.g. Wang et al., 2004; Zou et al., 2007) have not given attention to this phase; however, it is very important before embarking on risk identification. Some other studies (Zwikael & Sadeh, 2007; Osipova & Eriksson, 2013; Hwang et al., 2014) have recognised risk management planning as the first step of the risk management process, to be performed before embarking on the subsequent phases. This stage simply defines the process to be followed and requires no major changes (Hillson, 2002). The preliminary phase of risk management processes has ensured that the project objectives are clearly defined and understood. Risk management planning plays very prominent role over all the phases of risk management processes as it boosts the possibility of success of the other phases and ensures that the level, type, and visibility of risk management are proportionate with both the risk and the importance of the project to the organization (Caltrans, 2012). It is also beneficial, as it allows

adequate time and resources for risk management activities (PMI, 2008). Accordingly, proper risk management planning is helpful to identify the objectives, approaches and resources to perform risk management activities (Cagliano et al., 2015). The deliverable or output of the risk management planning is the risk management plan.

3.3.1 The risk management plan

Risk management planning yields the output or deliverable referred to as the risk management plan (RMP), which explains how risk management will be organized and implemented within the project (PM1, 2008). The RMP specifies the extent to which risk management for the projects will be carried out and the frequency of risk management meetings and risk register updates. It also provides details of the project risk management team members involved in the project and outlines a budget for the risk management tasks (Caltrans, 2012). Thus, it becomes an integral component of the project management plan. The literature review has identified a number of components of the risk management plan, which include:

- **Methodology**: This section specifies the approaches, tools, and data sources to be used to undertake risk management on the project (PMI, 2008). It is important to clarify in the RMP whether the risk management approaches intend to deal with both opportunities and threats.
- **Roles and responsibilities:** This section specifies the task of the project team members regarding their responsibilities for each of the risk management activities in the RMP (PMI, 2008; Caltrans 2012). This is important for proper accountability in risk reporting and follow up actions if required.
- **Budgeting:** This section states the amount of resources allocated to the entire project team for carrying out risk management tasks on a particular project (PMI, 2008; Caltrans 2012).
- **Schedule of project management:** states when and how often (e.g., weekly, bi-weekly or monthly) risk management processes will be undertaken for a particular project at its stage of development or throughout the entire project lifecycles.
- **Risk reporting format:** This specifies how the results of risk management processes will be documented, analysed and communicated to the key project stakeholders. Caltrans (2012) recommends that a copy of the risk register should accompany RMP.
- **Tracking:** This section explains the process to be followed to track identified risks and recognised occurrence of new risks that are likely to affect the project delivery success (Caltrans, 2012). It also states how risk activities will be

documented for the advantage of the current projects as well as for future needs and lessons learned.

3.3.2 Risk management planning: Tools and Techniques

3.3.2.1 Planning meetings and analysis

Planning meetings to develop RMP are held by the project team members. Participants at these meetings could include but are not limited to the project manager, project risk manager, nominated project team members and stakeholders, and anyone in the organisation with capability and responsibility to manage the risk planning and implementation tasks (PM1 2008). According to PIM (2008); these meetings aims to achieve the following:

- Defining high level plans for performing risk management tasks
- Developing risk management cost elements and scheduling activities to be included in the project budget and schedule respectively
- Establishing or reviewing risk contingency reserve application approaches
- Assigning risk management responsibilities
- Generation of risk register templates containing risk classifications and descriptions of terms like levels of risk, probability by type of risk, impact by type of objectives and the probability and impact matrix to be directed to a particular project
- Summarising the outputs of these meetings in the RMP.

3.4 Risk identification

As shown in Figure 3-1 section 3.1, risk identification starts with the basic question: what risks could trigger threats or opportunities to the project objectives? This approach is about making the best use of the available information and experience as of the time of making the decision (Choudhry et al. 2014). Al-Bahar and Crandall (1990) define risk identification as the process of thoroughly and constantly identifying, classifying and evaluating the initial significance of risks in construction projects. Hence, risk identification is an interactive and continuous process. The reason for this is that new risks could emerge as the project progresses through its life cycle (PMI, 2008)

According to (PMI, 2008) it is the process concerned with determining which risks may affect the project and documenting their characteristics. There is a consensus by most researchers (as shown in Table 3-1), that it is the first phase of any risk management

process, in which risks are identified, shortlisted and recorded. However, previous studies have shown that risk identification in the construction industry is not robust. The effect of this could be negative, as risks are being carried along without clear knowledge. In-view of this problem, Hlaing et al. (2008) advise that risk identification should be performed as part of project's initial definition process, along with project planning, budgeting and scheduling. They further point out that those other activities cannot be done realistically without taking risk into consideration. In some cases, the risk identified can cause the project to be abandoned or modified greatly during the planning stage.

3.4.1 Risk identification Process framework

The identification process involves the identification of major potential sources of risk associated with the project objectives (Osipova & Eriksson, 2013). The identification process is aimed at ascertaining the potential risks, i.e., anticipating those events that are likely to either negatively or positively affect the projects. Risk identification involves determining which risks might affect the project and registering their characteristics. It is advisable for as many stakeholders as possible to be involved in the identification process (PMI, 2008). Al-Bahar and Crandall (1990) proposed six steps involved in the identification process, as shown in Figure 3-3. Identification of the project risk can involve all or a combination of these individuals and groups: the project manager, project team members, the risk management team (if assigned), experts who are not members of the project, customers, end users, other project managers, stakeholders and risk management experts (Hillson, 2002; PMI, 2008). According to APM (1997), the purposes of the risk identification process are to identify where risks might arise, identify what we might do about this risk in proactive and reactive response terms and identify what might go wrong with our response. The author agrees with the view taken by Caltrans (2012) which emphasises that the risk identification process is about providing answers to the question represented in Figure 3-2: 'What risks might negatively or positively affect achievement of the project objectives?' (PMI, 2008).

Risk identification is considered by many researchers as the most important stage of the risk management process, as the actions of risk analysis and response depend on the identified risk. The success of the identification process to some extent will depend on the experience and knowledge of the individual involved in the identification process, particularly in the specific projects where risk is to be identified.

The starting point for identifying project risks is the preliminary checklist of potential risks that may affect the project objectives. The second step in the risk identification process, which is concerned with all of the reasonable possibilities associated with the realization of each primary source of risk included in the preliminary checklist.

Attempting to identify all risks in a construction project is time consuming and an exercise in futility. According to Osipova & Eriksson (2013), even with a thorough identification process it is impossible to predict all the risks. Since it is difficult to manage all the potential risks in construction projects, it is advisable to focus on key risks (El-Sayegh & Mansour, 2015). Preferably, the most significant risks should be identified and controlled (El-Sayegh, 2008). There are a number of tools and techniques for identifying risks in construction project some of which are discussed in the next section.

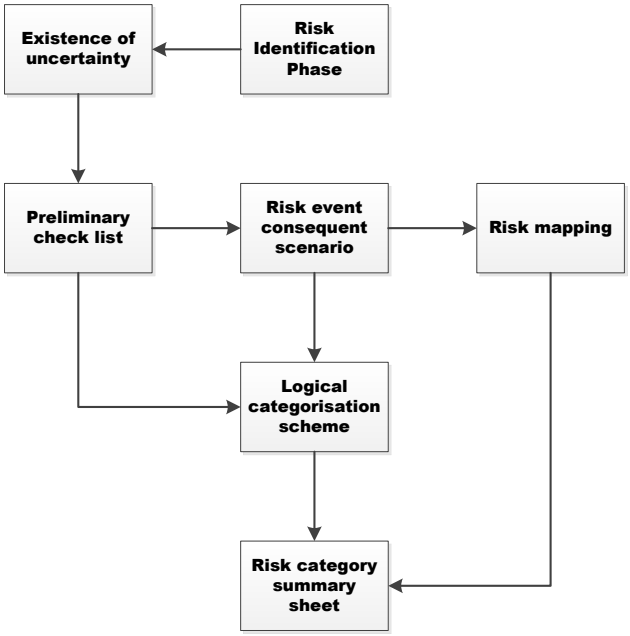

Figure 3- 3: Risk identification process framework, (Source: Al-Bahar and Crandall, 1990)

3.4.2 Risk identification tools/techniques

At each phase of the risk management process framework outlined in Figure 3-2, there exists a number of different risk management techniques to be used. Accordingly, there

are several different risk identification techniques employed in the construction industries, some of which are summarised in Table 3-2

Table 3- 2: Risk Identification Techniques

Techniques	Descriptions	Representative literature
Checklists	Basically a thorough list of risks that could affect any project. Can be generated based on historical information and knowledge that has been gathered from prior similar projects and from other sources of information (e.g. studies in the literature). Should be reviewed at the completion of a project to include new lessons learned and improved for use on impending projects. Simple and easy to use	(Ward and Chapman, 1996; Forbes et al., 2008; PMI 2008)
Brainstorming	This is an information-gathering and creative technique; one of the most leading and extensively used risk identification techniques. It aims at getting a comprehensive list of risks. In a brainstorming session, ideas pertaining to project risks are generated under the governance of a facilitator in an extensive group exercise. The exercise is typically performed by the project team, usually with a multi-disciplinary set of experts that are not part of the team.	(Lyons & Skitmore, 2004; Tang et al., 2007; PMI, 2008; Forbes et al., 2008)
Historical data	The risky aspect of a project by can be assessed by drawing from prior experience of similar previous projects. Probably could be a good option, as most projects involve a number of reasonably standard and recognised risk situations but this doesn't work in all situations.	(Bajaj et al., 1997; Lyons & Skitmore, 2004: Hlaing et al., 2008)
Expert judgement	Experts with relevant experience of risk management of similar project can be consulted to identify risks. The project manager should identify such experts and engaged them to assess all aspects of the projects and propose possible risks based on their previous experience and field of technical know-how.	(Tang et al., 2007; PMI, 2008, Caltrans, 2012; Choudhry et al., 2014)
Interviewing	Risks are identified by interviewing experienced project participants, stakeholders and subject matter experts.	(Dey & Ogunalana, 2004; PMI, 2008; Grimaldi et al., 2012)
SWOT analysis	This entails examining the project from each of the SWOTs (strengths, weaknesses, opportunities, and threats) in a workshop environment to increase the breadth of identified risks by including the internally negated risks. It starts with identifying the strengths and weaknesses of the organisation using brainstorming. This is followed by identifying any opportunities that emerge from organisational strengths and any threats emanating from organisational weaknesses.	(Hillson, 2002; PMI, 2008)

Force field analysis	Extensively used in strategic decision-making to identify positive and negative influences on achievement of objectives. Could easily and simply be adopt and adapted to identify project risk by determining factors that would oppose project success (threats) as well as those that would facilitate it (opportunities)	(Hillson, 2002)

Further details on other risk identification techniques, such as influence diagrams, cause-and-effect diagrams, failure mode and effect analysis, hazard and operability studies, fault trees and event trees can be found in Hillson (2002), Ahmed et al. (2007), PMI 2008 and Grimaldi et al. (2012)

According to Al-tabtabai and Diekmann (1992) the primary basis for the identification of risks is historical data, experience and insight. However, it is unlikely that the same risk may occur on similar projects, since each construction project is unique. In view of this it was recommended by Bajaj et al. (1997) that if no one in the project team has had experience of a similar project, suitably qualified people should be called in for the brainstorming exercise. This again depends on the availability of qualified individuals, especially in a developing nation. According to Dey and Ogunlana (2004), today's projects are increasingly being managed using various risk management tools and techniques; however, the application of those tools depends on the nature of the project, the organisation's policy, the project management strategy, the risk attitudes of project team members and the availability of resources. The literature review has suggested that there is no single best method for risk identification and that a combination of techniques should be employed (Hillson, 2002; Choudhry et al., 2014). It is therefore recommended that with respect to the techniques used, the risk identification exercise should be the collective responsibility of all the parties involved and conducted as a group exercise rather than on an individual basis, as the experience of an individual can be limited (PMI, 2008; Caltrans, 2012; Choudhry et al., 2014).

3.4.3 Usage of risk identification techniques

This literature review has found that, of the numerous risks identification techniques that exist; only a few of them are used in practice as summarised in table 3-3

Table 3- 3: Usage of risk identification

Key theme	Author	Location	Main findings
A survey of contractors' approaches to risk identification during the tendering and estimation stage	Bajaj et al. (1997)	New South Wales, Australia	Questionnaires together with checklists and scenario building were the most frequently used
A study various structural and cultural factors concerned with the implementation of risk management at the conceptual phase of a project life cycle	Uher and Toakley (1999)	Australia	checklists, brainstorming and flowcharts were the most frequently used
A survey of risk in Queensland engineering construction industry	Lyons and Skitmore (2004)	Australia	Brainstorming, followed by case based approach and checklist.
Investigation of contractors' perceptions of risk at the estimating and tendering stage	Hlaing et al. (2008)	Singapore	Analysis of historic data was ranked first (54%) followed by the case based approach (48.7%) and intuition/judgement/experience (43.6) in identifying risk at the estimating and tendering stage
Investigation of the risk management techniques used in the Chinese construction industry	Tang et al. (2007)	China	Brainstorming followed by consulting experts and checklists were the most commonly used
Investigation risk analysis and management among 37 experts in the UK construction industry	Simister (1994)	U.K	Checklist was the most frequently used risk identification techniques

All of the commonly used risk identification techniques could, in principle, be equally used to identify opportunity as well as threat but the experience of most project teams is to focus on negative issues when using these methods (Hillson, 2002). To avoid the negative effect of such attitudes, Hillson (2002) recommended the use of additional techniques (such as SWOT analysis, force field analysis & constraint and assumption analysis) to broaden the techniques.

3.4.4 Importance of construction risk identification

Since the process of risk analysis and risk treatment or management may only be performed on the identified risks, risk identification is a vital step that needs to be taken before risk can be analysed and an appropriate remedial actions can be determined (Hlaing et al., 2008). In fact, it is assumed that the main benefits of risk management

arise from the identification rather than the analysis stage. The identification of each source of risk and its components allows the risk items to be separated from each other. The early identification of risk and uncertainty will draw the attention of the project management team to the strategies required for the control and allocation of risk, e.g. through the choice of contract strategies (Mill, 2001). Furthermore, early identification of risk can enable project constraints and appropriate cost estimates to be determined (Ward et al., 1991).

3.4.5 Identification and classification of highway infrastructure project risk

Generating a risk checklist is another method of risk identification. To advance the identification process, risks can be categorised according to their sources, impacts or project phases. As an integrative part of risk identification, risk classification attempts to structure the diverse risks affecting a construction project (Zou et al., 2007). Some form of classification or categorization is required for clear understanding of the risks involved in the highway infrastructure project to be managed (Bing et al., 2005; Al-Bahar and Crandall, 1990). Different methods of risk classification have been used to classified risks associated with highway infrastructure construction projects. For example, hierarchy risk break-down structure (HRBS) can be used to classify highway infrastructure project risks into external and internal risks (El-Sayegh, 2008; Zayed et al., 2008). However, Bing et al. (2005) used a meta-classification approach on the basis of three levels of risk for PPP/PFI projects, namely: macro level risks; meso level risks and micro level risk. Every other form of classification used stems from external and internal classifications.

The HRBS allows risks to be separated into those that are related to the management of internal resources, which are relatively controllable, and those that are prevalent to the external environment, which are relatively uncontrollable (Tar and Carr, 2000; El-Sayegh 2008). Figure 3-4 is an example of the use of HRBS to classify risks in construction projects. A main approach based on the categorization of risk sources into external and internal factors for developing HRBS propose that external risks are those that comes from area outside the range of organisation control while internal risks are those that an organisation's management can directly control and influence. Risk at the external level includes risks associated with political, economic, social, weather or legal conditions. Basically, these risks stem from risk events occurring outside the system limits of a project (risks sourced exogenously), but whose impact or consequences cross

the project limit to impact upon the project and its performances (Bing et al., 2005). Internal risk factors tend to be more manageable and differ among projects. These are risk events and their consequences occurring within the system limits of the project, i.e., risks sourced endogenously (Bing et al., 2005). Within each of these main classifications (external and internal), sub-classifications relating to the nature of the specific risk can be made. The method of classification proposed by Tar and Carr (2000), El-Sayegh (2008) and Zayed et al. (2008) is adopted in this study, because it is a useful approach to facilitate a strategic approach to highway infrastructure project risk management. Furthermore, it could also reveal circumstances where common approaches to risk analysis, response strategies, monitoring and reviewing could be adopted in the risk management process. This in turn can lead to developing effective risk management strategies (PMI, 2008)

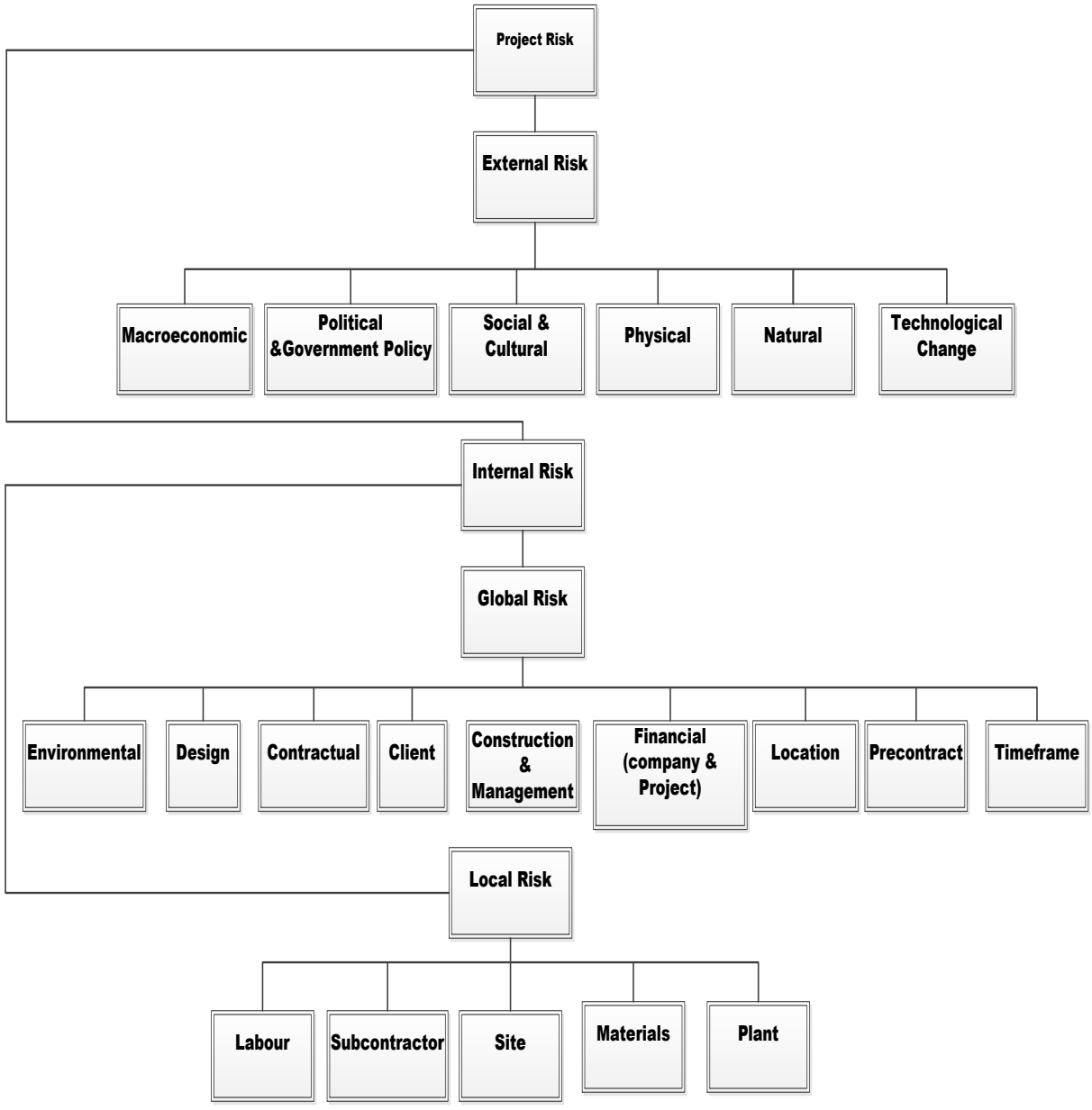

Figure 3- 4: Generic HRBS for construction project, (Source: Tar and Carr, 2000).

3.4.6 Risk checklists for highway infrastructure projects

According to Wang et al. (2016), risk identification aims at recognising, judging and classifying the risk that an infrastructure project could be exposed to. The risk identification phase element comprises of an extensive literature review, generation of risk checklists or a risk catalogue, a risk breakdown structure (RBS) tool and an expert interview to determine the most significant risks (Hashem et al., 2015). At the end,

there should be a comprehensive list of risks that threaten the project objectives or opportunities to be exploited.

3.4.7 Project risk register

A risk register is a tool (generally a spreadsheet) that can be used by the project teams to report and record the identified risks, the results of the analysis of those risks, the risk owners and the agreed response strategies throughout the project lifecycles (Patterson and Neailey, 2002; PMI, 2008; Caltrans 2012). It is the deliverable of risk identification and can be updated in the subsequent or successive phases of the other risk management processes. Since risk management methodology is not a one-off process, the risk register should be used as a living document and updated as an on-going and dynamic process throughout the project lifecycles and throughout the phase of each of the risk management processes (Patterson and Neailey, 2002; Caltrans, 2012). Caltrans (2012) recommends full review and update of the risk register to be performed at the start of each successive phase of the project. According to Patterson and Neailey (2002), a project risk register offers a number of benefits:

- It provides a platform on which the mitigation actions and decisions can be made in the future. This is achievable by ensuring greater understanding and acceptance of the visible risks.
- It enables the risk reduction and mitigation plans within the project itself to be document.
- It provides the means of auditing and maintaining historical data for a project. This can, in turn, ensure that clear and concise communication takes place both within and external to the project which will result in improving the project performance, especially in the areas of time, cost and quality
- According to Caltrans (2012), it communicates project risks and enables the team members to understand the status of the risks as a project moves from inception toward completion

Project delivery can be improved by setting up and keeping a risk register over the lifecycle of a project. The risk register ensures that project risks, analysis and responses are communicated through the project phases, so that risks are known, understood and effectively managed. Consideration of in-house historical databases is probably the best source of data to assess the occurrences or consequences of risk events (Creedy et al., 2010). Regrettably, in most developing countries in Africa, particularly in Nigeria, these databases are unavailable or disorganised. In fact, it has been reported that there

is little information relating to actual risk management in developing countries (Reza et al., 2016; Iqbal et al., 2015). In fact, Ahmadi et al. (2017) emphasize that lack of documented inventory of the relevant data of the finished projects as the one of main issues for highway project risk management in developing countries. Hence, a risk register could be a useful tool for identifying; analysing and categorising the risks associated with highway infrastructure construction projects in Nigeria and provide the means of developing a cost-effective method of managing them.

3.5 Risk analysis phase

Risk analysis, commonly referred to as risk assessment in some studies (e.g. Osipova & Eriksson 2013; Zeng et al., 2007; Zayed et al., 2008), and determines the possibility of occurrence of the risk and the corresponding consequences on the performance of project objectives, such as time, cost, quality and scope, as shown in Table 3-1.). Its goal, according to Osipova & Eriksson (2013), is to prioritise events that have to be managed. According to Mills (2001), it sets out to quantify the effects of the major risks that have been identified. It arises as a result the answers to the questions: What is the possibility that this risk will occur? And what is the severity of the consequence if it does occur? Thus, risk analysis is the evaluation of how the identified risk factors can affect the success of the project and its performance by assessing their significance (possibility of occurrence and consequences). According to Zou et al. (2007), it is an intermediate process between risk identification and risk response that integrates uncertainty in a qualitative and quantitative manner to evaluate the potential impact of risks. As illustrated in Figure 3.1, risk analysis exists in two forms (qualitative and quantitative). The qualitative aspect attempt to address the most important risks associated with the construction projects while the quantitative aspect attempts to ascertain the overall effects of these risks of the projects in the probabilistic terms of cost and schedules. One of the objectives of this research is to identify and analyse the important risks associated with highway infrastructure construction projects in Nigeria. The performance of highway infrastructure construction projects can be improved by early identification and analysis of the risks associated with them. The literature suggests that the risk analysis phase of the risk management methodology is considered as the most difficult, as it involves the evaluation of the probability of risk occurrence and their impact on the performance of project objectives. The risk analysis and evaluation process forms the basis for decision making between different management

strategies (Fisher and Robson, 2006). Fundamentally, this phase aims at combining the effects of the identified and assessed risks into an overall comprehensive approach to give the basis for evaluating the effectiveness of the risk management framework and establish the footings for subsequent risk management strategies. According to Alhawari et al. (2012), the risk analysis process yields a detailed description of every valid risk, its severity, impact, priority, probability and impact estimates

Depending on the available data, time and money, organisational need and the organisational risk management maturity level, risk analysis can be performed either qualitatively or quantitatively.

3.5.1 Qualitative risk analysis

Qualitative risk analysis involves prioritising the identified risk for further action, such as risk response (Hillson, 2002; PM1 2008; Caltrans, 2012). The priority of the identified risks is assessed by using the product of their possibility of occurrence and the corresponding consequence. It is basically based on experts' experiences (Choudhry et al., 2014). Ahmed et al. (2007) point out that quantitative data are not readily available when needed, and hence they suggest that qualitative risk analysis using subjective assessment is most appropriate for risk management. Although the subjective approach is influenced by individual bias, preference and expertise, Ahmed et al. (2007) argue that it lays foundation for risk assessment where it is vital to highlight risk events that are possible, rather than an exact prediction of a catastrophic event. Furthermore, Bowers and Khorakian (2014) advise that the bias associated with qualitative assessment can be minimised by using systematic techniques such as risk mapping to enhance the transparency of the analysis. It is considered in the thesis that ascertaining definitions of the levels of possibility of occurrence and consequence can decrease the influence of bias. In addition, scrutinizing the quality of the information available on project risks could further assist in clarifying the evaluation of the risk's importance to the project.

It has been suggested that qualitative risk assessment is preferred by organisations because expert opinion is the best source available rather than unreliable measurement (Ahmed et al., 2007). Hence, it is noted that practitioners tend to have a higher preference for qualitative approaches such as intuition and experience, or experts' judgement (Akintoye and MacLeod, 1997; Tang et al., 2007). Osipova & Eriksson (2013) warn that with subjective assessment the problems of different perceptions arise,

since each group of players could have its own view of the importance of risk. Therefore, they recommend that the involvement of many players is crucial to get a comprehensive view and avoid narrow and biased perspectives of project risks.

The performance of construction projects can be effectively improved by focusing on high priority risks. The literature suggests that qualitative risk analysis is a quick and cost effective means of establishing priority for planning risk response and lays the footings for quantitative risk analysis if necessary (PMI, 2008). It is advised that the qualitative risk analysis should be revisited during the life cycle of the project to ensure it is up-to-date with changes in the project risks. Bowers and Khorakian (2014) point out that, since the requirement for the management in many projects is to understand the relative severity of risk, qualitative risk analysis techniques are often sufficient and the quality of data does not justify more sophisticated techniques.

3.5.2 Qualitative risk analysis tools and techniques

There are a number of tools/techniques for performing qualitative risk analysis, including risk possibility and consequence analysis, a risk possibility and consequence matrix, expert judgement, fault tree analysis (FTA), event tree analysis (ETA) and failure mode and effect analysis, (FMEA). Some of these techniques, such as FTA, ETA and FMEA, could be used either in a qualitative manner or integrated with a quantitative approach, if necessary (Bowers and Khorakian, 2014). A few of these techniques are discussed below. For more details on qualitative risk analysis techniques, see Ahmed et al. (2007); PMI, 2008; Grimaldi et al. (2012); Bowers and Khorakian (2014).

3.5.2.1 Risk possibility and consequence analysis

Risk possibility and consequence analysis (a qualitative risk analysis tool), also referred to as risk probability and impact assessment/risk ranking/risk index (Grimaldi et al., 2012) investigates the possibility of the occurrence of a specific risk. Risk possibility analysis investigates the potential effects on the project performance, such as time, cost or quality, and involves both a negative effect for threat and a positive effect for opportunity (PM1, 2008). The possibility and consequences of each of the identified risks are assessed by means of interviews with experts with experience in that particular project. Table 3-4 is an example risk possibility and consequence rating definition,

considering the negative impact, adapted from PMI (2008) and Caltrans (2012), with slight modifications

Table 3- 4: Example of possibility and consequence ratings of risk on key project objectives

Consequence Rating	1 (Very low)	2 (Low)	3 (Medium)	4 (High)	5 (Very high)
Cost	Insignificant cost increase	< 5 % cost increase	5 - 10% cost increase	10 - 20% cost increase	> 20% cost increase
Time	Insignificant lapses	< 1 month lapses	1 – 3-month lapses	3 – 6-month lapses	> 6-month lapses
Quality	Insignificant quality deficiency	No safety issues, deficiencies accepted by project team	No safety issues, deficiencies need PM approval	Quality may be accepted through mitigation	Unaccepted quality
Scope	Insignificant scope decrease	Variations in project limits with < 5 % cost increase	Variations in project limits with 5 - 10% cost increase	Sponsor disagrees that scope satisfies purpose & need	Scope does not satisfy purpose & need
Possibility	1 - 9%	10 - 19%	20 - 39%	40 - 59%	60- 99%

3.5.2.2 Risk Possibility & Consequence Matrix

A possibility and consequence matrix, also referred to as a probability-impact matrix/probability and impact grids/risk mapping/ (Ahmed et al., 2007; PMI, 2008; Bowers and Khorakian, 2014) is a process where the possibility and consequences of each risk are assessed against stated scales. Its position on the matrix shows the relative importance of each risk, and high/medium/low zones can be defined, enabling risk to be ranked and prioritised based on past experience or organisational procedures, as shown in Table 3-5, for example. The red zone signifies high importance, yellow is medium importance, and blue is low importance. The aggregate of the possibility number and the consequence number define the risk score: e.g. for a risk having medium possibility and a high consequence is in the red zone and its consequence score is 12.

The approach can be used for assessing opportunity as well as threat, although the focus of this research is on threat. This approach provides a simple format for showing the relative importance of risk events (Ahmed et al., 2007)

Table 3- 5: Example of risk possibility and consequence matrix

Risk possibility and Consequence Matrix for highway construction projects						
Possibility Rating	5: Very high					
	4: High					
	3: Medium					
	2: Low					
	1: Very low					
		1: Very low	2: Low	3: Medium	4: High	5: Very high
Consequence rating						

3.5.2.3 Expert Judgement

Expert judgement is needed to assess the possibility and consequence of each risk to determine its position in the matrix shown in Table 3-5. Experts are mainly those with experience in similar projects that occurred in the past (PMI, 2008). The project managers, project risk manager and other members of project risk management team can all play a part in the expert panel. Akintoye and MacLeod (1997) argue that this approach cannot regarded as formal method of risk analysis but informal, as it relies largely on experience. On the contrary, recent research emphasises that expert opinion is the best source of information and plays prominent role in risk analysis (Ahmed et al., 2007; Choudhry et al., 2014).

3.5.3 Quantitative risk analysis

Quantitative risk analysis involves analysing numerically or probabilistically the effect of identified risks on the performance of overall project objectives (Hillson, 2002; PMI, 2008; Caltrans, 2012). It is usually a follow-up analysis of the risk that has been prioritized by the qualitative process, if required. It could be used to give to those risks individually or to evaluate the cumulative effect of all risks affecting the project and to present a quantitative approach to decision making in the presence of uncertainty. Quantitative risk analysis involves the use of complicated tools/techniques such as Monte Carlo Simulation, Sensitivity analysis, decision tree analysis, failure mode and effect criticality analysis. For further details on quantitative risk analysis techniques see Ahmed et al. (2007), PMI (2008), Grimaldi et al. (2012), Bowers and Khorakian (2014). One of the techniques that is common to both qualitative and quantitative risk analysis is the use of expert judgement. According to PM1 (2008), expert judgement is required for quantitative risk analysis to identify potential cost and schedule impacts, to evaluate

probability, and to define inputs (such as probability distribution) into the tools. It also comes into action for the interpretation of data. Experts should be able to ascertain the weaknesses of the tool as well as their relative strengths. Practitioners tend to avoid using these approaches due to their complexity and complicated processes compared to the qualitative method. Since the application of these techniques also depends on the project risk management capability of an organisation, it is rarely adopted in most developing countries, particularly Nigeria, where the risk management capability of highway project organisations is very poor (Salawu and Abdullah, 2015). According to PM1 (2008), resource availability (e.g. time and money) and the need for qualitative and quantitative statements about the risk and impacts determine which methods to use on any particular project.

3.5.4 Differences between Qualitative and Quantitative risk analysis methods

Some of the differences between qualitative and quantitative risk analysis methods are summarised in Table 3-6

Table 3- 6: Differences between qualitative and quantitative risk analysis methods

Qualitative	Quantitative	Representative literature
Tends to be cheap, flexible and quick to apply	Complicated, expensive and requires considerable expert effort but this may be justified in large-scale projects	(Patterson and Neailey, 2002; Bowers and Khorakian, 2014)
Tend to be subjective	Offers more rigour and objectivity but very demanding in term of data	(Bowers and Khorakian, 2014)
Relies on human judgement with inevitable scope for personal bias, experience and preference	Typically involves statistical analysis of historical data drawn from database of experience developed in previous projects	(PM1, 2008; Bowers and Khorakian, 2014)

3.5.5 Risk analysis Process framework

The schematic view of risk analysis process is shown in Figure 3-5. The initial phase in the risk analysis and evaluation process is the gathering of data appropriate to the risk exposure to be evaluated. These data are likely to be from historical records that the contractors have experienced in the previous projects. According to Al-Bahar and Crandall (1990), such data are not readily available in sufficient quantities and subjective assessment is likely to be needed. The evaluation of risk is critically dependent on the expert in the field, who might be unlikely to have much technical knowledge of the analytical tools of risk analysis. After the risk of a project has been identified and analysed, applicable risk response strategies should then be employed to manage the risks in the construction project's execution.

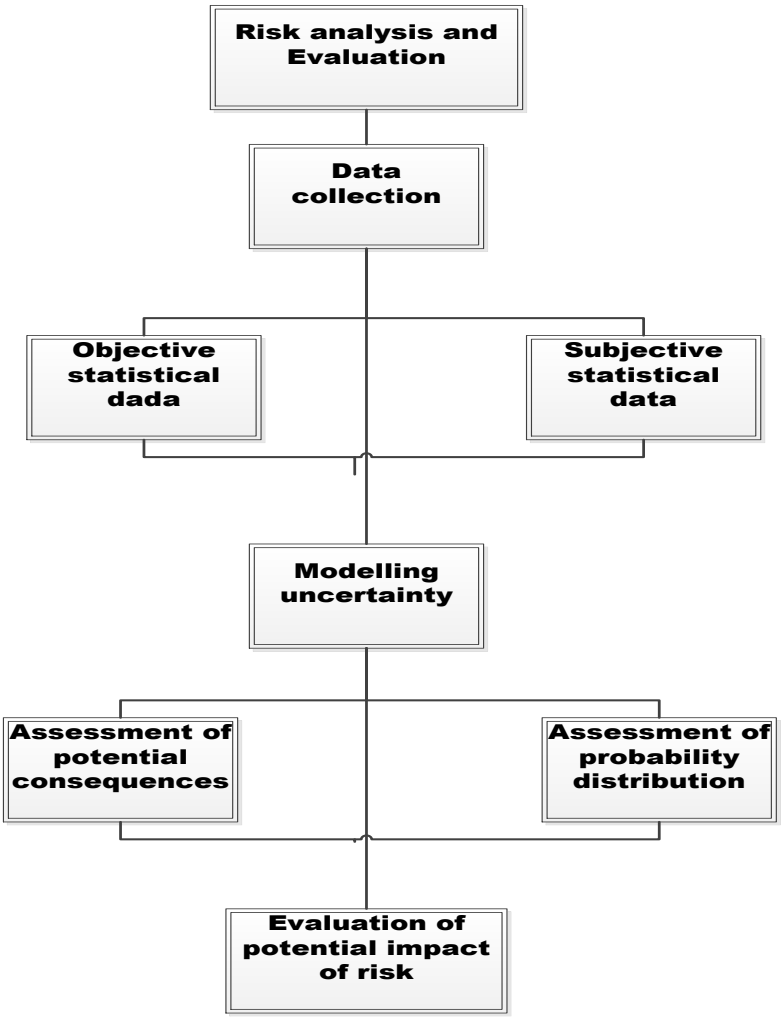

Figure 3-5: Risk analysis and evaluation process framework, Source: (Al-Bahar and Crandall, 1990)

3.5.6 Application of risk analysis tools/techniques

A survey of risk analysis and management in construction industry in the UK found that the organisations relied on intuition/judgement/experience to manage risk in construction project followed by sensitivity analysis (Akintoye and Macleod, 1997). The preference for sensitivity risk analysis compared to other formal risk analysis techniques could probably be attributed to its answers to a whole range of 'what if' questions; it is comparatively simple to use and has the ability to focus on a particular estimate. Patterson and Neailey (2002) explained that the reason for the preference in the adoption of qualitative risk analysis by decision makers compared to quantitative risk analysis is the simplicity in application and cost-effectiveness. Quantitative risk analysis techniques on the other hand are time consuming and costly.

According to the literature review, there seems to be greater preference for the adoption of traditional and qualitative risk management approaches compared to the quantitative approach. Tang et al. (2007) investigated the application of risk analysis techniques in the Chinese construction industry and noted that joint evaluation by key participants was most frequently used, followed by qualitative analysis. The use of quantitative techniques was given the lowest rating. The most popular techniques used were subjective or intuitive assessment and sensitivity analysis.

The decision makers find that these methods are very easy to use due to their simplicity and use of subjective information and judgement and support provided by computerised spreadsheet packages. Other more advanced risk analysis techniques such as probabilistic risk analysis or simulation, although highly developed in theory, have not been found to be widely used in assessing and managing risk. The literature review shows that size of the project and their complexities determine the utilization of risk management (Ahmed et al., 2007; Caltrans, 2012).

Lack of awareness of appropriate techniques and tools has been identified for low implementation of risk management process in Sub-Saharan Africa, for example, in Ghana (Yirenkyi-Fianko and Chileshe, 2015) and in Malawi (Kululanga and Kuotcha, 2010).

3.5.7 Importance of construction project risk analysis

The primary aim of risk analysis is to eradicate as much as possible the potential negative impact and to increase the level of control of the risk (Zou et al., 2007). Notwithstanding, the process of risk management does not attempt to eradicate all risks but rather to identify appropriate strategies to support project stakeholders to manage them. Ward and Chapman (1991) examined the possible role of risk analysis in project management, as shown in Figure 3.6. To start with, risk analysis can assist in accepting/rejecting decisions and the project design, and subsequently in the development of risk management strategies. Where projects involve contracting parties, risk analysis can help to determine the appropriate apportionment of project risks. In the construction context, risk analysis should be undertaken by project key stakeholders to reduce uncertainty and risks, pursue efficiency, and check the risk/expected – cost balance. In addition, risk analysis should be used to determine how risk should be allocated to contracting parties (Ward et al., 1991). The output of the risk analysis process is a comprehensive description of all valid risks and estimates of their severity, impact, priority and probability (Alhawari et al., 2012).

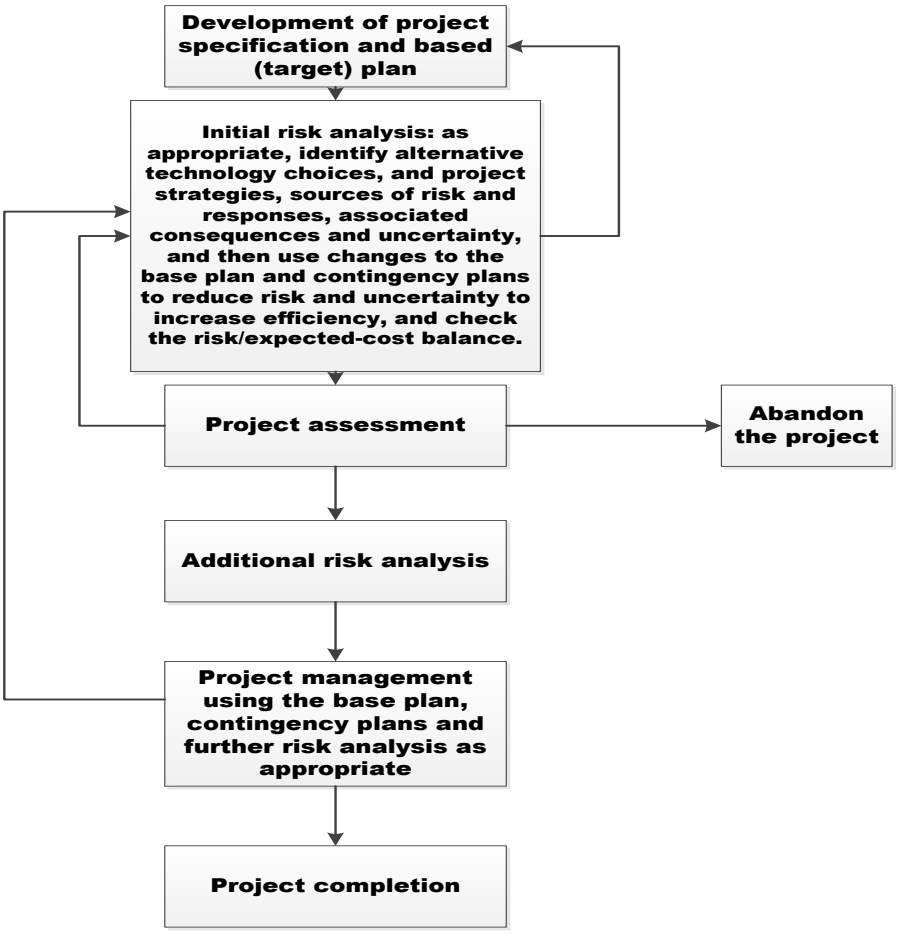

Figure 3- 6: Basic role of risk analysis, (Source: Ward and Chapman, 1991)

3.6 Risk response Phase

The essence of this phase of risk management methodology is to develop strategic alternatives and determine strategies to enhance opportunities and decrease threats to the performance of construction project objectives. According to Hillson (2002), this phase exists to develop responses to the identified risks that are suitable, affordable and achievable. It is a follow-up risk management strategy after the identification and analysis phase is completed to determine suitable risk management strategies (Schatteman et al., 2008). According to Osipova & Eriksson (2013) this phase is directed at finding a way of dealing with risks. In essence, this phase exists to continue with the risk management activities from the previous phases (identification and analysis). The literature review identified several risk response strategies, including: avoid, transfer, mitigate, accept, exploit, and share (PMI, 2008); avoid, transfer, mitigate, exploit, share, enhance and accept (Caltrans, 2012); avoid, transfer, mitigate and accept/retain (Hillson, 2002; Wang and Chou, 2003). Table 3-1 provides further details of various risk response strategies as identified by different researchers. These strategies can be grouped according to their purpose on the project objective, as shown in Figure 3.7.

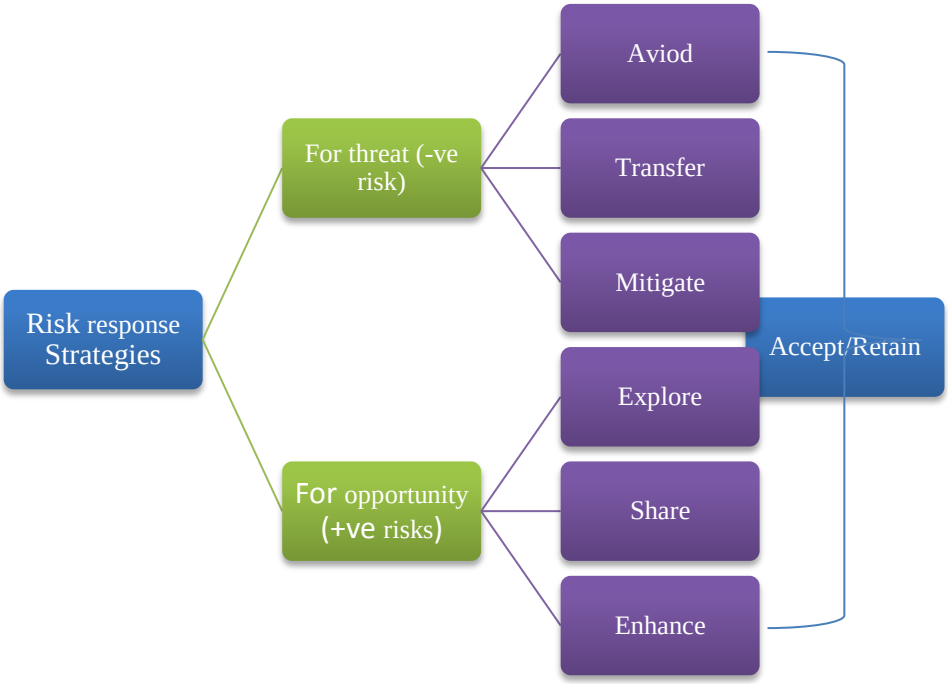

Figure 3. 7: Risk response strategies framework, (Source PMI, 2008; Caltrans, 2012)

Shen (1997) identified two types of risk management strategies: preventive action which comprises strategies to reduce, avoid, or transfer risks at the earliest stage of construction projects and remedial strategies for minimising the effects of risks when they have already occurred.

As recommended by PMI (2008) the strategy or combination of strategies most likely to be effective should be chosen for each risk. For effective implementation and monitoring purposes, each of the response strategies should be attributed ownership (Hillson, 2002).

3.6.1 Risk avoidance

Risk avoidance involves executing the project using alternative approaches (e.g. extending the schedule, changing the strategy or reducing the scope) that do not involve the risk, yet aiming to achieve the project objective (PMI, 2008; Schatteman et al., 2008; Caltrans, 2012). Some risks that emerge at the early stage of the project development can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise (PMI, 2008). Risk avoidance could also involve recognising the increased possibility of failure and abandoning the project.

According to Al-Bahar and Crandall (1990) risk avoidance is a useful, fairly common strategy to respond to risk. By avoiding risk, the potential loss that may be accrued by risk exposure will not be experienced but on the other hand, the potential gains (opportunity) that may be obtained from assuming that exposure will also be lost. Some risks can be avoided but not all; in some cases it could be too expensive and time consuming.

3.6.2 Risk transfer

Risk transfer involves identifying a suitable party to take responsibility, liability and management of the risk should it occur (Hillson, 2002, Caltrans, 2012). It aims at ensuring that the risk is owned and managed by the party best able to deal with it effectively (Caltrans, 2012). It usually involves taking risk insurance, outsourcing or subcontracting an activity or activity group and modifying the contract terms and conditions to the client or third party (Wang and Chou, 2003; Schatteman et al., 2008).

The findings of risk analysis and management conducted in the UK construction industry by Akintoye and MacLeod (1997) indicated that the industry showed more tendencies to transfer risk associated with construction projects. In contrast, the findings of Lyons and Skitmore (2004) who studied the Queensland Construction industry and Hlaing et al. (2008) who also studied construction contractors in Singapore

found that risk reduction was the most frequently used risk response method in dealing with risk, although in each case, risk transfer was close behind.

3.6.3 Risk mitigation

Risk mitigation involves the process of reducing the possibility of occurrence and/or consequence of an adverse risk event to be within tolerable or acceptable threshold limits (Wang and Chou, 2003; PMI, 2008; Caltrans, 2012). Early action to decrease the possibility and/or consequence of a risk is usually preferable and more effective than attempting to repair the damage after the risk has occurred. The risk management process does not aim to eradicate all risks from a project but to identify suitable strategies to assist project stakeholders in managing those risks (Zou et al., 2007)

3.6.4 Risk acceptance/retention

This strategy is adopted when a suitable response strategy cannot be identified to respond to the project risk (PMI, 2008; Caltrans, 2012). Accepting/retaining a risk implies agreeing to address the risk should it occur. Risk acceptance strategy could be passive or active. Passive acceptance implies taking no action except to register the risk and allow the project team member to deal with risks as they occur. Setting a contingency reserve (such as time, money or resources) in place is the most common active strategy for dealing with risks (PM1, 2008). Thus, the two options to be considered when retaining/accepting a risk are to either develop a contingency plan should a risk occur or take no action until the risk occurs (Osipova and Eriksson, 2011).

The common response strategies for dealing with opportunity (positive risks) as shown in Fig.3.8 will not be discussed further, as it is not main emphasis of this research. For more details, see (Hillson, 2002; PMI, 2008; Caltrans, 2012).

3.7 Risk monitoring and review

This final but important phase of the risk management process has not been given prominence in many risk management framework studies. It involves constant monitoring of the status of the identified risk, identifying new risks, ensuring appropriate implementation of the agreed responses and reviewing their effectiveness throughout the project life cycle (Hillson, 2002; PMI, 2008). The current status of the identified risk can be assessed through project risk review meetings. Hillson (2002) recommends that project review meetings should include the status reports from the project team on key risks and agreed responses. Accordingly, the effectiveness of the

risk process itself has to be reviewed. This is to guarantee that the risk management requirements of the projects are satisfied. Monitoring will determine whether the periodic risk review and updating is performed, the risk management procedure is being followed and the remaining contingency reserves are still sufficient (PM1 2008; Caltrans, 2012). Monitoring and review will result in recommending alternative strategies, drawing up a contingency plan, taking corrective measures and modifying the project plan (PMI, 2008). This approach is appropriate for both threats and opportunities.

3.7.1 Risk reviews and updating

It is the responsibility of the project risk management team to review the project risk register and risk response strategies quite often and update the project risk information accordingly. Caltrans (2012) outlines some of the responsibilities of the project risk management team as stated below:

- Identify, analyse, and plan response strategies for newly arising risks, and add them to the risk register.
- Review the implementation of risk response strategies, and assess their effectiveness.
- Re-evaluate existing risks, confirm that the assumptions are still valid, and amend the previous evaluation as necessary.
- Allocate further risk response strategies to the risk owner.

3.7.2 Risk monitoring and review: Tools and techniques

A number of risk monitoring and review tools and techniques were identified in the literature review. These are:

- **Risk re-assessment**

Risk monitoring and control usually results in new risks being identified, current risks being re-assessed and outdated risks being closed (PM1, 2008). Periodically, risk re-assessment should be scheduled. The level of frequency of the re-assessment is determined by performance of the project relative to its objectives.

- **Risk audits**

Risk audit is process of examining and recording the effectiveness of risk response strategies with identified risks and their root causes, as well as the effectiveness of the risk management process (PM1, 2008). It is the responsibility of the project manager to

ensure that risk audits are carried out at a reasonable interval, as stated in the project's RMP.

- **Status meetings**

Relevant attention should be given to project risk management during periodic status meetings. The level of attention required will depend upon the risks that have to be identified, their priority and difficulty of response (PM1, 2008). The more attention given to risk management practices, the easier it becomes.

3.8 Reflection on the above reviews

While risk management processes and techniques are well researched and implemented within the context of highway construction projects in developed countries, there is little evidence for research and implementation within the highway construction projects in developing countries particularly Sub-Saharan Africa. Lack of awareness of appropriate techniques and tools has been identified for low implementation of risk management process in Sub-Saharan Africa, for example, in Ghana (Yirenkyi-Fianko and Chileshe, 2015) and in Malawi (Kululanga and Kuotcha, 2010). Similarly, in the context of the Chinese construction industry, limited knowledge of risk management techniques has been identified as the limiting factor for its implementation (Tang et al., 2007). A proper application of risk management tools and techniques can add value to the performance of risk management in meeting project objectives. Despite the prominence of risk management practices within the context of highway construction project in developed countries, little is known regarding the highway construction practitioners' response and the techniques employed in the Nigerian highway construction industry. The probable reason could be due to lack of awareness or limited knowledge of the appropriate tools and techniques in the risk management area. These literature reviews have suggest that large scale infrastructure project risks can effectively and efficiently be managed with the application of risk management throughout the project lifecycle. This, there is a need for a comprehensive risk management framework that will effectively address the need for planning, identifying, analysing, responding to, monitoring and reviewing the risks associated with highway construction projects in Nigeria.

3.9 Chapter summary and literature gap

A comprehensive review of risk management processes has been undertaken and a generic risk management framework proposed, with five phases, which are: risk management planning, risk identification, risk analysis, risk response, risk monitoring and review. The risk management process offers a stable framework for identifying and understanding possible risk factors, assessing consequences and their uncertainties, and evaluating and choosing the best courses of action necessary to handle the identified risks in order to accomplish the desired project objectives.

The extensive review further identified the lack of research on risk management in highway projects in developing countries. In view of this, the current research is undertaken to develop a new risk management framework, by building on the existing studies and providing guidelines and assistance to facilitate the application of the framework.

Chapter 4: Research Methodology

4.1 Introduction

Deciding on a suitable research methodology is an important aspect of any research project. This chapter presents an overview of the concepts that guide researchers, highlighting their associated methods and data collection tools and their strengths and weaknesses. It is followed by the discussion of the research strategy adopted for this research and the rationale for doing so.

4.2 Research methodology

In the literature the terms research methodology and research methods are sometimes used synonymously. However, some researchers believe that these terms are different. Research method refers to the form of data collection and analysis techniques (Creswell, 2013; Bryman, 2012), whereas research methodology can be explained in terms of the overall approach to the whole process of the research study (Collis and Hussey, 2013). Every piece of research is undertaken to meet one or more objectives and the research methodology paves way for doing so. Saunders et al. (2016) have presented an overview of the overall approach to the whole process of research in the form of an onion, as shown in Figure 4-1. Within this the ideas with regard to research issues lie in the centre and many layers have to be removed before reaching the central position. These layers constitute the important consideration in determining research methodology for a particular research study. The key components of the layers identified from the outer to the inner layers are: research philosophy, the approach to theory development, methodological choices, strategies, and techniques and procedure. There are diverse explanations and definitions of these terms by different researchers but more consideration will be given to the approach proposed by Saunders et al. (2016), with some modifications with reference to other researchers, as it provides a comprehensive framework for the whole research process.

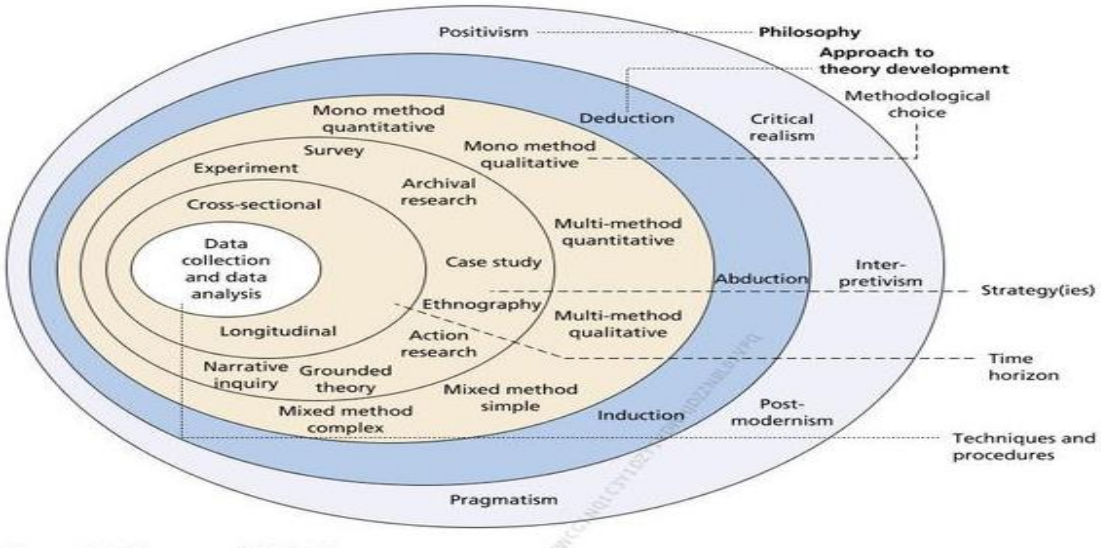

Figure 4- 1: The research 'Onion', (Source: Saunders et al., 2016)

4.3 Research philosophy and paradigms

4.3.1 Research philosophy

Research philosophy, according to Saunders et al. (2016) refers to a system of beliefs and assumptions about the development of knowledge. Every research study involves the development of knowledge in a particular field. At every stage in our research some types of assumptions are made. These assumptions include epistemological assumptions (assumption about human knowledge), ontological assumptions (about the reality we encountered in our research) and axiological assumptions (the extent and ways our own values influence our research process. These assumptions inevitably shape how we understand our research questions, the methodology we use and how we interpret your findings (Saunders et al., 2016; Creswell, 2013). A well-thought-out and consistent set of assumptions will constitute a credible research philosophy which will underpins the researcher's methodological choice, research strategy, data collection techniques and analysis procedures (Saunders et al., 2016)

4.3.2 Research paradigms

A paradigm can be defined as a collection of interrelated concepts or world-view (basic set of beliefs) that guides researchers (Fellows and Liu, 2008; Creswell, 2013). Different terminologies are used in the literature to refer to how situations are viewed. For example, Fellows and Liu (2008) use the term paradigm, meaning a theoretical framework that represents the system by which people view events; Creswell (2009) uses the term world-view, meaning a basic set of beliefs that guide actions. Research

methods cannot be viewed separately from the ontological and epistemological position espoused by the researcher (Dainty, 2008), as they are integral part of each other. In line with this view, Creswell (2009) states that the types of beliefs held by individual researchers determine whether to choose a qualitative, quantitative or mixed method approach in their research.

The chosen paradigms guide the researchers through the philosophical assumptions that guide the researcher and the choice of tools, instruments, participants and methods adopted in the study (Denzin and Lincoln, 2000; Creswell, 2009). There are various paradigms that are employed to guide research. Table 4-1 shows a comparison of five main research paradigms identified in the literature. Some of their strengths and weaknesses are also highlighted in Table 4-2.

Table 4- 1: Comparison of five research paradigms, (Source: Fellows & Liu, 2008; Creswell 2013; Saunders et al., 2016).

Research paradigms	Philosophical view/assumptions			Typical research methods
	Ontology (nature of reality or being)	Epistemology (what constitute acceptable knowledge	Axiology (role of value)	
Positivism Positivists believe that there are observable facts which can be observed and measured by an observer who remains uninfluenced by the observation and measurement.	Real, external, independent One true reality (universalism)	Scientific methods Observable and measurable fact	Value-free research Researcher is detached, neutral and independent of what is being researched Researcher maintains objective stance	Typically, deductive, highly structured, large samples, measurement' typically. quantitative method of analysis but a range of data can be analysed
Interpretivism/Constructivism Interpretivists believe that truth and reality are social constructs, rather than existing independently out there; hence researchers should try to determine truth and reality from the participants' collective views.	Complex, rich. Socially constructed through culture and language Multiple meanings, interpretations, realities. Flux of processes, experiences, practices	Theories and concepts too simplistic. Focus on narratives, stories, perceptions and interpretations New understandings and worldviews as contribution	Value-bound research Researchers are part of what is research Subjective Researcher interpretations key to contribution Researcher reflexive	Typically, inductive. Small samples, in-depth investigations, qualitative methods of analysis but a range of data can be interpreted.
Pragmatism This is not committed to any one system of philosophy and reality. Pragmatists look to the what and how to of research, based on the intended consequences-where they want to go with it.	Complex, rich external 'Reality' is the practical consequences of ideas Flux of processes, experiences, practices	Practical meaning of knowledge in specific contexts 'True' theories and knowledge are those that enable successful actions Focus on problems, practices and relevance. Problem solving and informed future practice as contribution.	Value-driven research Research initiated and sustained by researcher's doubt and beliefs Researcher reflexive	Following research problems and research question Range of methods: mixed, multiple, qualitative, quantitative, action research Emphasis on practical solutions and outcomes
Critical realism	Stratified /layered (the	Epistemological relativism	Value-laden research	Retroductive, in-depth historically

This is the belief that the world is socially constructed and subjective. The observer is part of what is being observed	empirical, the actual and the real) External, independent Intransient Objectives structures Causal mechanisms.	Knowledge historically situated and transient Facts are social constructions Historical causal explanation as contribution.	Researcher acknowledges bias by worldviews, cultural experience and upbringing Researcher tries to minimise bias and errors Researcher is as objective as possible	situated analysis of pre-existing structures and emerging agency. Range of methods and data types to fit subject matter
Postmodernism Emphasis the role of language and power relations, attempting to question accepted ways of thinking and give voice to the alternative marginalised views.	Nominal Complex, rich Socially constructed through power relations Some meanings, interpretations, realities are dominated and silenced by others Flux of processes, experiences, practices	What counts as 'truth' and 'knowledge' is decided by dominant ideologies Focus on absence, silence and oppressed/repressed meanings, interpretation and voices Exposure of power relation and challenge of dominant view as contribution	Value-constituted research Researcher and research embedded in power relations Some research narratives are repressed and silenced at the expensive of others Researcher radically reflexive	Typically, deconstructive –reading texts and realities against themselves In-depth investigations of anomalies, silences and absences Range of data types, typically qualitative methods of analysis

Table 4- 2: Strength and weaknesses of research paradigms

Research Paradigms	Strengths	Weaknesses
Positivism	• Internal and external validity, reliability and objectivity of the findings (Guo & Sheffield, 2008) • They can provide wide coverage of the range of situations • Can be fast and economical (Amaratunga et al., 2002)	• Objectivity requirement of scientific positivism requires that knowledge of the observer is excluded • Not very effective in understanding processes or the significance that people attach to actions. • Not very helpful in generating theories (Amaratunga et al., 2002)
Interpretivism/ Constructivism	• Have the potential to provide complementary insights, enriching understanding of the perspective of those that work in the sector (Dainty, 2008) • Contribute to theory generation • Ability to adjust to new issues and ideas as they emerge • Trustworthiness and authenticity of findings and fit with social norms and values (Guo & Sheffield, 2008)	• The interpretive paradigm could be laborious and time consuming. • Could be difficult to control the pace, progress and end-point of research process
Pragmatism	• Pragmatism paves way for multiple methods, diverse worldviews and diverse assumption, as well as diverse forms of data collection and analysis • Views current truth, meaning, and knowledge as tentative and as changing over time • Endorses a strong practical empiricism to determine what works (Johnson and Onwuegbuzie 2004).	• What is meant by usefulness or workability can be vague unless explicitly addressed by the researcher • Pragmatic theories have difficulty in dealing with the cases of useful but non-true beliefs or propositions and non-useful but true beliefs or propositions (Johnson and Onwuegbuzie, 2004).

Research paradigms are fundamental to all research inquiries and should precede the selection of research methods. The clear understanding of the philosophical position and orientation employed in the conduct of social research is essential as they help to clarify the rationales that underlie the choice of a particular research method or a combination of both. The decision of which paradigm to use basically affects the ways

in which data are collected and analysed and the nature of the knowledge produced (Dainty, 2008). Generally, from a philosophical perspective, ontology can be regarded as the conceptions of reality. Objectivist ontology understands social phenomena and their meanings as existing individually of social actions, while constructivist ontology understands that social phenomena are formed as a result of social interaction and are subject to changes. Epistemology denotes what is considered as an acceptable knowledge in a discipline (Bryman, 2012). Epistemological perspectives are bounded by the positivist view that the methods of the natural sciences should be applied to the study of social phenomena and the alternative orthodoxy of interpretivism, which sees a difference between the objects of natural science and people; in that phenomena can have different subjective meaning for each actor studied. Social constructivism is understood to be usually combined with interpretivism and is basically seen as an approach to qualitative research although it could be applicable to quantitative research Fellows and Liu (2008).

4.4 Research approaches

Recent studies (Creswell, 2013; Saunders et al., 2016) have identified three main approaches of reasoning: deductive, inductive and adductive approaches. This occupies the second layer of the research onion (Saunders et al. (2016) shown in Figure 4-1. Clear understanding of these approaches is relevant to the design of a research project. Following the identification of the philosophical view and research paradigm, it is important to decide how to approach the research study from the point of view of reasoning.

4.4.1 Deductive approach

A deductive approach entails the development of a theory that is subject to empirical investigation (Bryman, 2012; Collis and Hussey, 2013). This implies that from the existing knowledge in relation to the subject matter, the researcher proposes a theory that will be tested through empirical data. Saunders et al. (2016) further explain it in term of an approach in which the researcher begins with theory, often developed from reading of literature, and a research strategy is design to test the theory. The deductive approach is usually associated with quantitative research (Creswell, 2013; Saunders et al., 2016) and aims at testing or verifying a theory rather than developing it: the researcher advances a theory, collects data to test it, and reflects on its confirmation or

disconfirmation by the results (Bryman, 2012; Creswell, 2013). Figure 4-2 shows the process of the deductive approach in a research study.

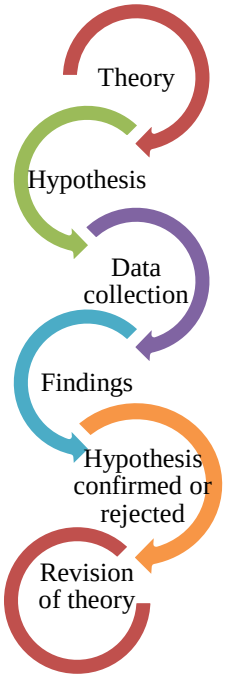

Figure 4- 2: The deductive process in research study (source: Bryman 2012)

4.4.2 Inductive approach

The inductive approach involves a situation where the research begins by collecting data to explore a phenomenon in order to generate or build a theory (Saunders et al., 2016). According to Collis and Hussey (2013), the inductive approach involves the development of theory from empirical reality, moving from individual observation to statement of general pattern, as opposed to the deductive approach, moving from general to particular. Unlike the deductive approach, it aims at theory building rather than testing. It is often associated with qualitative research (Creswell, 2013; Saunders et al., 2016). The process of the inductive approach begins with the researcher gathering detailed information from participants and then arranging this information into categories or themes. These themes are developed into theories or generalizations that are then compared with personal experiences or with existing literature on the topic (Creswell, 2013). Figure 4-3 demonstrates the inductive logic of research in a qualitative study.

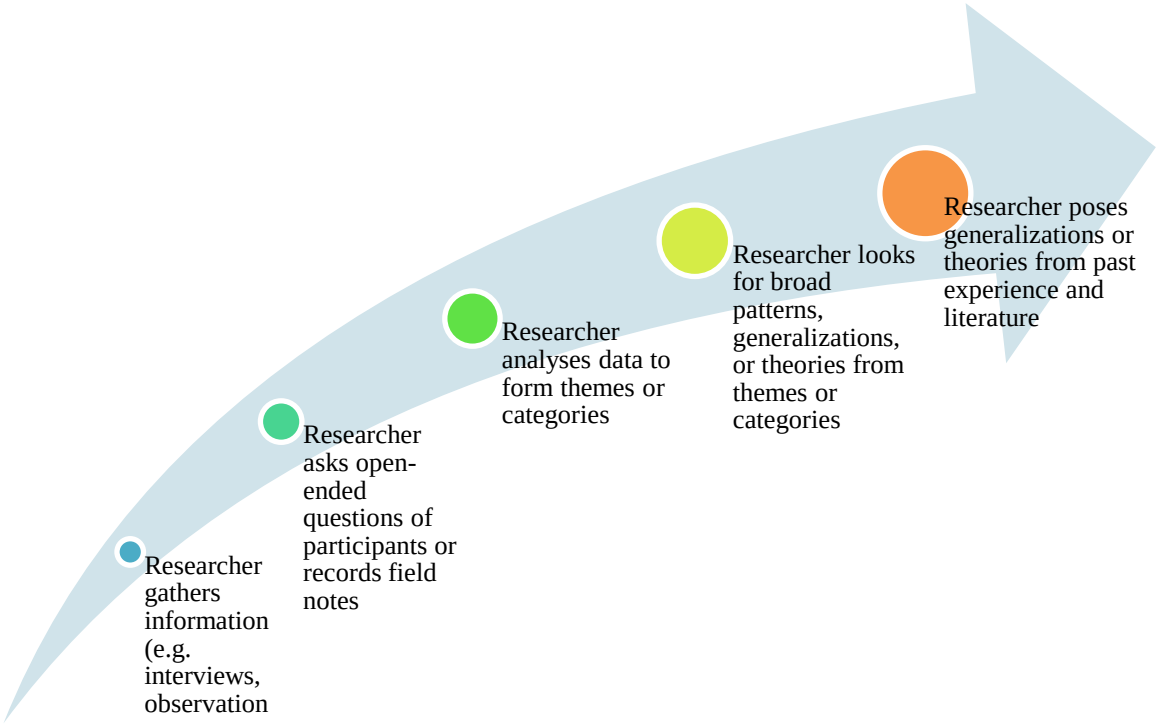

Figure 4- 3: Inductive logic of research in a qualitative study, (Source: Creswell, 2013)

4.4.3 Abduction approach

This approach involves the collection of data to explore a phenomenon, identify themes and explain patterns, to generate a new or modify an existing theory that is subsequently tested through additional data collection (Saunders et al., 2016). Whereas the deductive approach involves moving from theory to data and the inductive approach from data to theory, the abductive approach involves moving back and forth, in effect combining deduction and induction (Creswell 2013; Saunders et al., 2016).

Saunders et al. (2016) distinguishes between deduction, induction and abduction approaches in relation to logic, generalizability, uses of data and theory as shown in Table 4-3.

Table 4- 3: Differences between deduction, induction and abduction approaches: from reason to research (source: Saunders et al., 2016)

	Deduction	Induction	Abduction
Logic	In a deductive inference, when the premises are true, the conclusion must also be true	In an inductive inference, known premises are used to generated untested conclusions	In an abductive inference, known premises are used to generate testable conclusions
Generalizability	Generalising from general to the specific	Generalising from the specific to the general	Generalising from the interactions between the specific and the general
Use of data	Data collection is used to evaluate propositions or hypotheses related to an existing theory	Data collection is used to explore phenomena, identify themes and patterns and create a conceptual framework	Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent collection and so forth
Theory	Theory falsification or verification	Theory generation and building	Theory generation or modification; incorporating existing theory where appropriate, to build new theory or modify existing theory

4.4.4 Choices of research approaches

An important consideration now is which of the above approaches will suit a particular research study. According to Saunders et al. (2016) the choice of approaches depends on the emphasis of the research and the nature of the research topic. A deductive approach is recommended for a research topic where there is a wealth of literature from which one can define a theoretical framework and a hypothesis; for research into a topic that is new, exciting much debate and on which there is limited literature, the inductive approach is deemed more suitable, by generating data and analysing and reflecting upon what theoretical themes the data are suggesting. On the other hand, for a topic where there is a wealth of information in one context but far less in the context in which one is researching, an abductive approach is considered suitable, allowing an existing theory to be modified. It is also deemed more suitable to adopt an inductive approach for research that involves a small sample of subjects than with a large number, as in the deductive approach. A deductive approach can be quicker to complete, whereas

abductive and particularly inductive research can be much more time consuming (Saunders et al., 2016). Additionally, deductive approach is lower-risk compared to induction and abduction approaches (although they are at the risk of non-return of questionnaires. For the two latter approaches, the researcher has to live with the fear that no useful data patterns and theory will emerge.

4.4.5 Importance of choice of research approaches

A wise choice of research approach is important as: (a) it enables a more informed decision about research design to be taken; (b) it enables one to consider which research strategies and methodological choices will work well or not; for instance, if a research study is concerned about providing an answer to why something is happening rather than describing it, adopting an inductive approach would be more suitable instead of a deductive approach (Saunders et al., 2016); (c) knowledge of different research traditions allows the researcher to adapt the research design to cater for constraints (Easterby-Smith et al., 2012).

4.5 Research strategy

According to Bryman (2012) the general orientation to the conduct of social research is referred to as the research strategy. Different terminologies have been used across literature, such as research approaches (Creswell 2013) or research methodologies (Saunders et al., 2016). Various research strategies exist in literatures and the choice of which one to adopt depends on the research questions and objectives, the extent of existing knowledge on the subject area to be researched, the amount of time and resources available, and the philosophical underpinnings of the researcher (Saunders et al,, 2009), the type of research question, the extent of control an investigator has over actual behavioural events, and the degree of focus on contemporary or historical events (Yin, 2003). According to Creswell (2009), certain types of social research problems determine the specific approach to be used. The most important consideration about choice of strategy or strategies should be the one that best answers a particular research question and satisfies the objectives. The literature review has identified three fundamental research strategies (quantitative, qualitative and mixed methods research strategies) for the conduct of social research, as briefly discussed in the subsequent sections.

4.5.1 Quantitative research strategy

A quantitative research strategy emphasizes quantification in the collection and analysis of data. Creswell (2009) suggests that if the research problem calls for: (a) the identification of factors that influence an outcome, (b) the utility of an intervention, or (c) understanding predictors of an outcome, then a quantitative approach is best. It is also the best approach to use to test a theory or explanations. Approaches used in conducting quantitative research are: asking respondents questions through questionnaires and interviews; carrying our experiments, and desk study using data collected by others (Fellows and Liu, 2008). Some of the strength and weakness of quantitative research are outlined in Table 4-4

Table 4- 4: Strength and weaknesses of Quantitative research, (Source: Amaratunga et al., 2002; Dainty, 2008; Creswell, 2009; Saunders et al., 2016)

Strengths	Weaknesses
• Useful for obtaining data that allow quantitative predictions to be made • Data collection using some quantitative methods is relatively quick (e.g., telephone interviews). • Provides precise, quantitative, numerical data. • Data analysis is relatively less time consuming (using statistical Software). • The research results are relatively independent of the researcher (e.g., effect size, statistical significance). • It is useful for studying large numbers of people. • Testing and validating already constructed theories about how (and to a lesser degree, why) phenomena occur.	• Failure to provide detail meanings and interpretation even when significant, reliable and valid. • Employing a reductionist approach to examining social phenomenon (e.g. questionnaire survey) is likely to distance the enquiry from the social realities of the informant, thereby undermining its ecological validity

4.5.2 Qualitative research strategy

Qualitative research emphasises the description or interpretation in the collection and analysis of data. A qualitative approach is exploratory and is useful when the researcher does not know the important variables to examine. According to Creswell (2009), it is a suitable approach to adopt if a concept or phenomenon needs to be understood because little research has been done on it. Qualitative research has the purpose of gaining an in-depth understanding of the subject matter in question in its natural environment,

through employing a variety of interrelated interpretive practices. Some of the strengths and weaknesses of qualitative research are highlighted in Table 4-5.

Table 4- 5: Strengths and weaknesses of qualitative research (Source: Johnson & Onwuegbuzie, 2004; Creswell, 2009).

Strengths	Weaknesses
• It is useful for studying a limited number of cases in depth • It is useful for describing complex phenomena. • Provides understanding and description of people's personal experiences of phenomena • Can describe, in rich detail, phenomena as they are situated and embedded in local contexts.	• The results are more easily influenced by the researcher's personal biases and idiosyncrasies. • It generally takes more time to collect the data when compared to quantitative research. • Data analysis is often time consuming. • The objectivity of the data produced is often questioned

Bryman (2012) outlined the fundamental differences between quantitative and qualitative research strategies as shown in Table 4-6

Table 4- 6: Fundamental differences between quantitative and qualitative research methods (Source: Bryman, 2012)

	Quantitative	Qualitative
Principal orientation to the role of theory in relation to research	Deductive; testing of theory	Inductive; generation of theory
Epistemological orientation	Natural science model, in particular positivism	Interpretivism
Ontological orientation	Objectivism	Constructionism

4.5.3 Mixed methods research strategy

A mixed methods research strategy integrates quantitative and qualitative research methods within the same research inquiry. A mixed method design is useful when either the quantitative or qualitative approach by itself is inadequate to best understand a research problem or the strengths of both quantitative and qualitative research can provide the best understanding (Fellows and Liu, 2008; Creswell, 2009).

Mixed method research applies quantitative and qualitative research methods either sequentially (i.e., findings from one approach inform the other), concurrently (i.e., independently of each other) or in a transformational way (in this case, the data collection method involves a sequential or concurrent approach), to understand the phenomena of interest (Creswell, 2009). Saunders et al. (2016) provide a detailed and comprehensive explanation of how quantitative and qualitative techniques are combined in a mixed method research strategy, as shown in Figure 4-4

In a concurrent mixed method research strategy, quantitative and qualitative methods are used independently in a single phase of data collection and analysis, as shown in Figure 4-4. This strategy enables the findings/results of both strategies to be interpreted together, to give a richer and more comprehensive response to the research question compared to a single method. Collecting data qualitatively and quantitatively in the same phase of research to allow a comparison of how these data sets support each other implies the adoption of a concurrent triangulation design. In comparison to single method research, a concurrent mixed method provides richer data and compared to sequential methods it is quicker and more practical to undertake (Saunders et al., 2016)

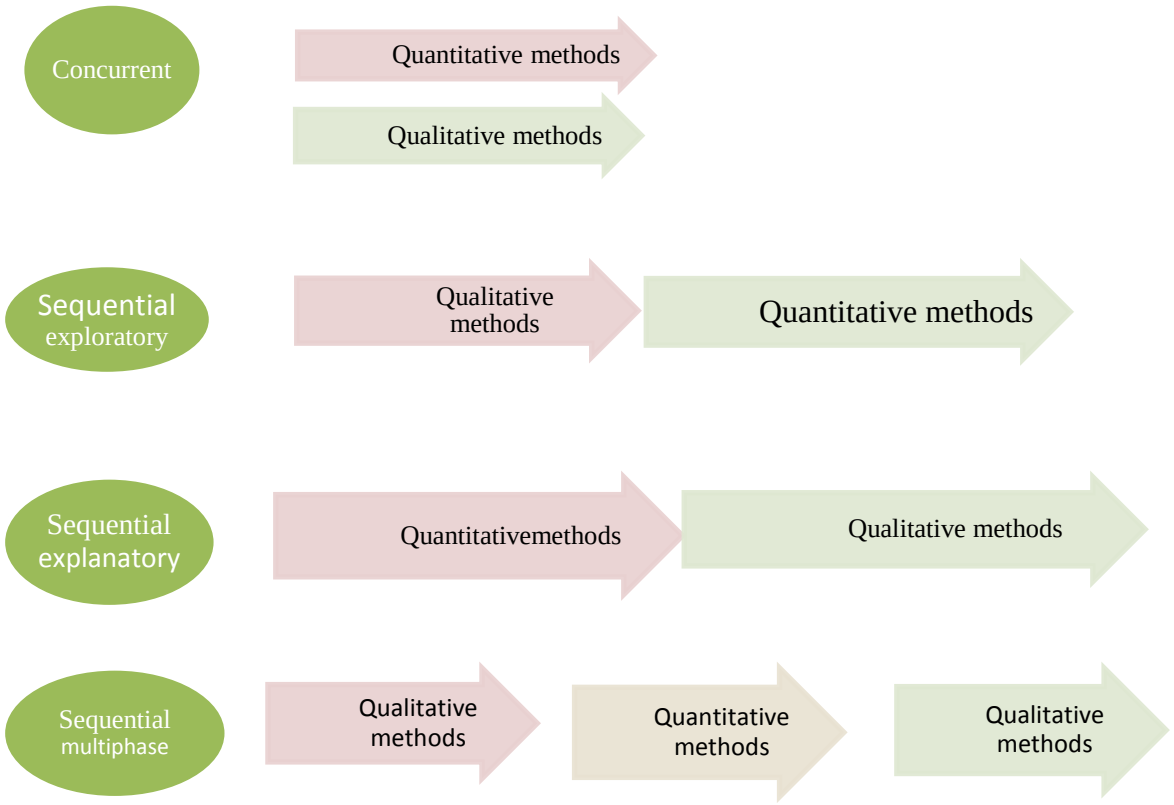

Figure 4- 4: Mixed methods research designs. Source: Saunders et al., 2016)

Unlike concurrent mixed methods research, sequential mixed methods research entails the collection of data and analysis in more than one phase, as illustrated in Figure 4.4. This process involves the researcher in following the use of one method with another so as to expand on the initial set of findings. In a double phase research design, this will result in two alternative mixed method research strategies: sequential exploratory research design (qualitative followed by quantitative) and sequential explanatory research design (quantitative followed by qualitative). Where mixed method research involves multiple phases of data collection and analysis, e.g. qualitative followed by quantitative and then by another phase qualitative, a sequential multiphase of mixed methods is being adopted.

Mixed methods are associated with a pragmatic world-view. The strengths and weaknesses of mixed methods are shown in Table 4-7

Table 4- 7: Strengths and weaknesses of mixed methods

Strengths	Weaknesses
• Employing quantitative and qualitative research techniques could be a very strong way to gain insights and results, to assist in making inferences and in drawing conclusions (Fellows and Liu, 2008). ▪ Enable the researchers to balance the strength and weakness of each approach (Abowitz and Toole, 2009) ▪ Help to enhance the reliability and validity of the results ▪ Can answer a broader and more complete range of research questions because the researcher is not confined to a single method or approach (Johnson & Onwuegbuzie, 2004) ▪ Can add insights and understanding that might be missed when only a single method is used Johnson & Onwuegbuzie, 2004) ▪ Qualitative and quantitative research used together produce more complete knowledge necessary to inform theory and practice (Johnson & Onwuegbuzie, 2004)	▪ It is expensive and time consuming ▪ Researcher has to learn about multiple methods and approaches and understand how to mix them appropriately.

4.6 Data collection and analysis

There are two main sources of data (secondary and primary) that are available to answer research question(s) or meet research objectives (Saunders et al., 2016). These data can be collected by means of specific instrument such as questionnaires, interviews, case studies and participant observation, and their analysis techniques will vary with respect to the types of data collected, which will be discussed in detail in the later section. Secondary data include both quantitative (numeric) and qualitative (non-numeric) data. Data collected newly or first hand by the researcher is referred to as the primary data. The technique for collecting data is referred to as the research method (Bryman, 2012).

4.6.1 Questionnaire

A valid questionnaire will ensure accurate data to be collected that truly measure the concepts that researcher is interested in, while a reliable one will imply that these data are collected consistently. For the data collected to be valid and reliable, the question should be designed in such a way that it can be clearly understood by the respondent in the way intended by the researcher and that the respondent's response can be understood by the researcher in the way intended by the respondent. To achieve this,

Saunders et al. (2016) propose 4 stages that must occur if the question is to be both valid and reliable, as shown in Figure 4-5.

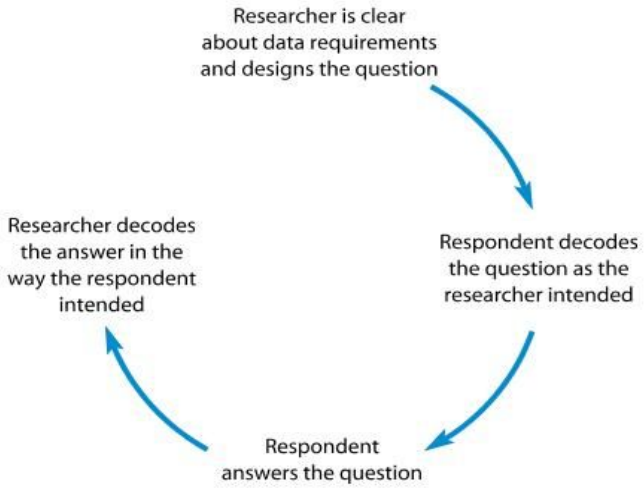

Figure 4-5: Stages that must occur if the question is to be valid and reliable, Source: (Saunders et al., 2016)

In designing an individual questionnaire, the researcher has the freedom to either adopt or adapt questions used in other questionnaires or develop his or her own. Adopting or adapting questions could be useful should the researcher wish to make comparison of the findings with those of other research studies. This will enable reliability to be assessed. It is also proved to be more efficient than formulating one's own questions, provided the data can be collected to answer one's research questions and satisfy the objectives (Saunders et al., 2016).

4.6.2 Interviews

Saunders et al. (2016) recommend that the nature of any interview should be consistent with the research questions and objectives, the research purpose and the research strategy adopted. Interviews can be classified as structured, semi-structured or unstructured, among many other ways.

- Structured interview involves the administration of an interview scheduled by an interviewer which aims at enabling each interviewee to be given the same context of the questions.
- Semi-structured interview questions are usually in general form and are likely to vary as the interview progresses.

- Unstructured interview is usually an informal way of asking questions and the phrasings and sequencing of questions will vary from interview to interview (Bryman, 2012; Saunders et al. 2016).

Data collection using semi-structured or in-depth interviews could be beneficial under the following circumstances: (a) it is suitable for the purpose of the research; (b) the importance of establishing personal contact; (c) the nature of the data collection questions and (d) the amount of data required and the completeness of the process (Saunders et al., 2016).

4.6.3 Case study

A case study is a detailed study of a single individual, group/organisation, or event/project (Fellows and Liu, 2008). Yin (2003) defines a case study as an empirical research study that examines phenomena in their natural settings. Yin (2009) proposes two main types of case study, as single case studies and multiple case studies`. In a multiple case study strategy, the cases are studied in their real life situations with dependence on multiple sources of evidence which aim at generalising findings into a theory (Sutrisna and Barrett, 2007).

Case studies can be undertaking qualitatively or quantitatively or as a combination of both. Data for case studies can come from a variety of sources, including observation, interviews, questionnaires, reports and archival records (Fellows and Liu, 2008). According to Fellows and Liu (2008), a case study has at least four uses in construction management research, including as a source of insight; to describe phenomena; creating a project biography and illustrative anecdotes. This research has adopted a qualitative case study for the following purposes meeting the second and third objectives of the current research: to identify and analyse the important risks associated with highway infrastructure construction projects in Nigeria and to investigate the risk management processes and techniques currently used in highway construction projects in Nigeria and evaluate their efficiency.

4.7 Research design (methodology) for this study

This study aims to develop a risk management framework to improve the performance of highway construction infrastructure projects in a developing country. To achieve this aim, some specific objectives were set out. The overall plan of how to meet these objectives constitutes the research design. It consists of specific objectives set out to meet the research aim, stipulates data collection sources and the means of collecting and

analysing these data and also discusses some ethical issues and limitations that might be encountered (Saunders et al., 2016). The process implemented for this research is shown in Figure 4-6. To gain the state-of-the-art knowledge in risk management involving civil engineering construction infrastructure projects, an inductive qualitative research methodology is engaged through a comprehensive review of literature on: Construction project risk management, risk management methodology, risk management in civil engineering infrastructure projects and risk management in highway construction projects. The outcome of literature review has been presented in an earlier section.

Knowledge and observation of practice followed by the literature review conducted in stage 1 was used to establish the problem statements and justify the research through identifying gaps, and the research aim and objectives of the study. At stage 2, data are collected by means of: questionnaire distribution through an online link, (LimeSurvey), and distribution by hand. During this stage, interviews are conducted in four selected case studies of highway construction projects to identify and analyse the important project risks and to investigate the risk management processes and techniques currently used in highway construction projects in Nigeria and evaluate their effectiveness.

Stage 3 involves the synthesis of data collected in stage 2 and uses it as a basis to develop a risk management framework to improve the performance of highway construction infrastructure projects in Nigeria. Stage 4 is the review and evaluation of the developed risk management framework by experts and practitioners

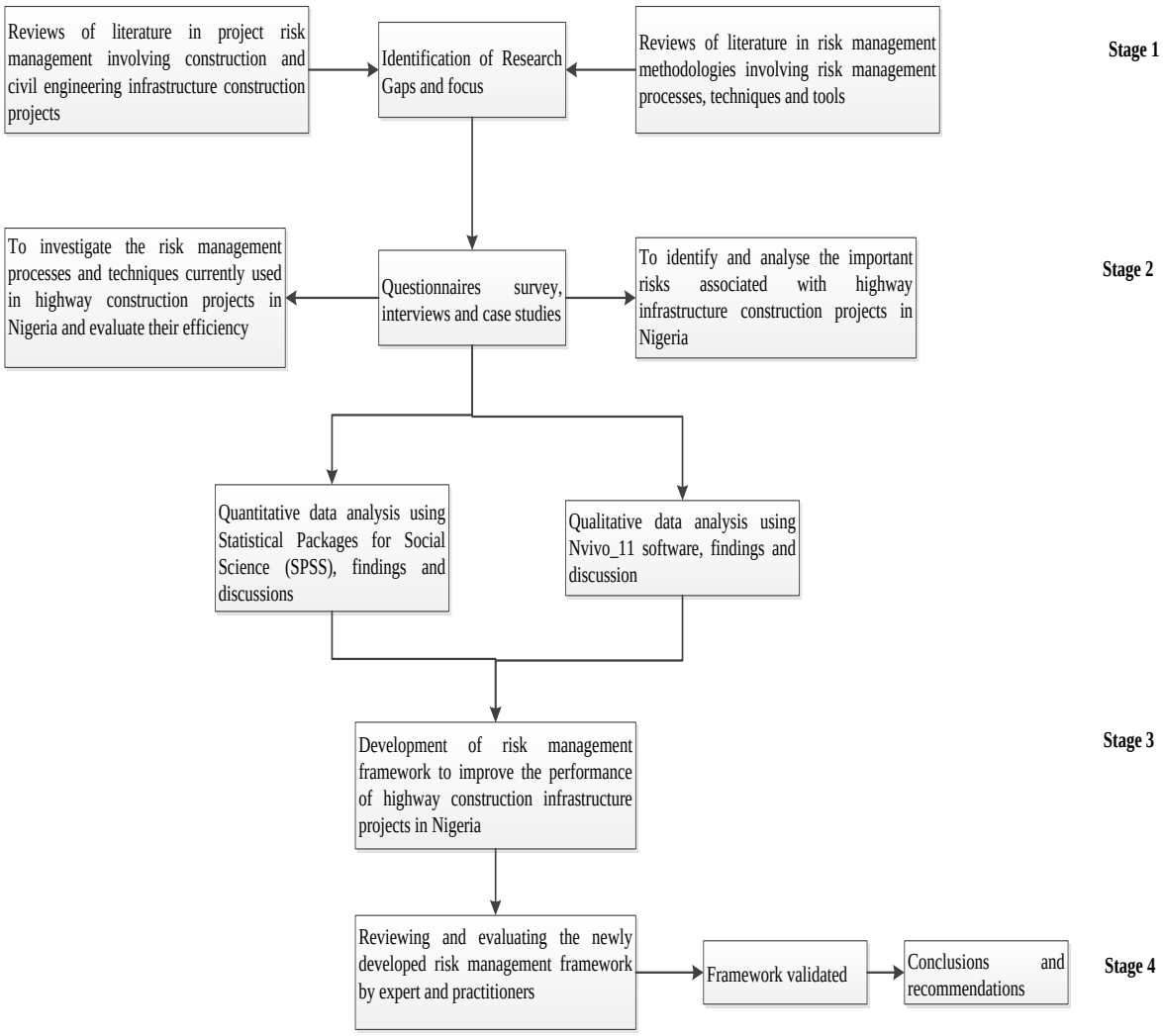

Figure 4-6: Research process adopted for the study

4.7.1 Selected Research Philosophical paradigm

Literature reviews identified five research paradigms that guide the researchers in philosophical assumptions regarding the researcher and the choice of tools, instruments, participants and methods adopted in the study (Table 4.2). Saunders et al (2015) recommends the adoption of pragmatic paradigms where the research problem does not clearly call for one particular type of knowledge or method to be adopted. The current research aims at developing risk management framework to improve the performance of highway construction infrastructure projects in Nigeria. Understanding of risk associated with highway infrastructure projects in Nigeria is pertinent to achieve this aim. Understanding of risks associated with highway construction infrastructure projects cannot be best understand by adopting one particular type of knowledge or one method. Since pragmatic paradigm paves way for multiple methods, diverse worldviews and diverse assumption, as well as diverse form of data collection and analysis (see Table 4.2), it is considered suitable and selected for this research as it satisfied the research aim and objectives. From Ontological philological stand, reality matter to pragmatist as practical effects of ideas and knowledge is valued for enabling actions to be carried out successfully; for a pragmatist, research begins with a problem, and aim to contributes practical solutions that inform future practice (Saunders et al 2016).

4.7.2 Selected research approach

Three forms of research appraoches of reasoning (Inductive, deductive and abuductive) were discussed in the previous section. The choice of which one to select as explained in section 4.4 depends on the emphasis of the research and the nature of the research topic; availability of time, and the question of audience. A recap of the current research as aiming at developing risk management framework to improve the performance of highway construction infrastructure projects in Nigeria. In general there is wealth of knowlegde in risk management in highway construction infrastruction projects but in the context of developing countries and particularly Nigeria, there is dearth of knowledge in this area. Since deductive approach is most suitable where there is wealth of knowledge in subject area and inductive approach is preferred where there is limited knowledge in the subject area, the current research has adopted the combination of deductive and inductive approach. It is possible and advantagious to combine deductive

and inductive approach within the same research investigation as recommeded by Saunders et al (2016). Considering the time factor, the abductive approach will not be suitable as it is more time consuming compared to that of inductive or deductive or combination of both recognising that the PhD research is within a limited period of time

4.7.3 Selected research strategy

Drawn from the pragmatic philosophical paradigms, this study has adopted a mixed methods research strategy. A mixed method design is useful when either the quantitative or qualitative approach by itself is inadequate to best understand a research problem or the strength of both quantitative and qualitative research can provide the best understanding (Fellows and Liu, 2008; Creswell, 2009). The risks associated with highway infrastructure construction projects in developing countries, especially Nigeria, cannot best be understood using just one strategy. For this reason, a combination of strategies is selected to provide the best understanding of risks associated with highway infrastructure construction projects in Nigeria and also to investigate the risk management processes and techniques currently used to manage these risks and develop a comprehensive risk management framework to improve the performance of highway construction infrastructure projects in developing countries.

As illustrated in Figure 4-4, there are four types of mixed method strategies, among which the concurrent approached is preferred as explained in section 4.5.3. Employing mixed method strategies concurrently is a useful approach to provide a comprehensive analysis of the important risks associated with highway infrastructure construction projects in Nigeria as well as investigating the risk management processes currently used in highway construction projects in Nigeria. Mixing quantitative and qualitative techniques will enable the researcher to balance the strengths and weaknesses of each approach; and to substantiate the data obtained by various methods so as to validate the result of the research (Bryman, 2004).

4.7.4 Selected research methods

As previously explained under research methodology section, research method refers to the form of data collection and analysis techniques. The two methods usually considered for data collection are quantitative and qualitative methods. Quantitative is usually used as a term for any data collection techniques which produces numerical data, such as like questionnaires or data analysis procedures like graphs or statistics,

while the term qualitative is usually used for any data collection techniques like interviews that produce non-numerical data (Saunders et al., 2016). However, it is important to note that some qualitative research data can be analysed quantitatively. In the same way, in the research design that uses questionnaire, respondents can be asked to complete some opened-ended questions in their own words. This research used both quantitative and qualitative data collection methods.

4.7.5 Sampling

There exist two main types of sampling techniques: probability (also known as representative sampling) and non-probability sampling (non-random sampling). Probability sampling is usually associated with a quantitative research strategy, while non-probability sampling is associated with a qualitative research strategy. Saunders et al. (2016) propose four stages involved in probability sampling process: (a) identify a suitable sample frame based on your research question(s) and objectives; (b) decide on a suitable sample size; (c) select the most appropriate sample techniques and select the sample; (d) check that the sample is representative of the target population. The five main techniques available for the selection using probability sampling are: simple random; systematic random; stratified random; cluster and multi-stage. The techniques for selection in non-probability sampling are: quota sampling; haphazard sampling; purposive sampling and volunteer sampling (Saunders et al., 2016). Selection of the most suitable sampling techniques is vital to enable research questions to be answered or to meet the research objectives. For management research, Saunders et al. (2016) suggest that the research question(s), objectives and choice of strategy may necessitate non-probability sampling.

Non-probability purposive sampling is selected in this research to choose from among the highway construction professionals from different geo-political zones in Nigeria. The rationale for this preference is that it enables the researcher's judgement to select cases that will best answer the research questions and meet the research objectives (Saunders et al., 2016). Accordingly, it is also reasonably cost effective and produces high response rate.

4.8 Quantitative data collection method

4.8.1 Questionnaire survey

Questionnaire is one of the most widely used data collection method in construction project risk management research. Questionnaires can be in closed question form (each question having a pre-determined number of responses determined by the researcher) or open questions form (having no pre-determined number of responses determined by the researcher). Questionnaires can be used for both quantitative and qualitative research strategy but they are not particularly suitable or recommended for research that involves a large number of open-ended questions (Saunders et al., 2016). They work best with standardized questions. Therefore, they tend to be used for descriptive or explanatory research. Descriptive research will enable the researcher to identify and describe the variability in different phenomena, while in explanatory research, it will enable the researcher to examine and explain relationship among variables. They are different kinds of questionnaires, as shown in figure 4-7. A questionnaire survey was mainly adopted in this research. The choice of questionnaire will be influence by the factors relative to the research questions and objectives. Internet questionnaires administered through an emailed hyperlink, give greater control, as most people read and respond to their email. For delivery and collection questionnaires, the researcher could check who has answered the questions at the collection point. On the other hand, an interviewer-completed questionnaire enables the researcher to ensure that the respondent is the targeted participant. This offers the advantage of improving the reliability of the data.

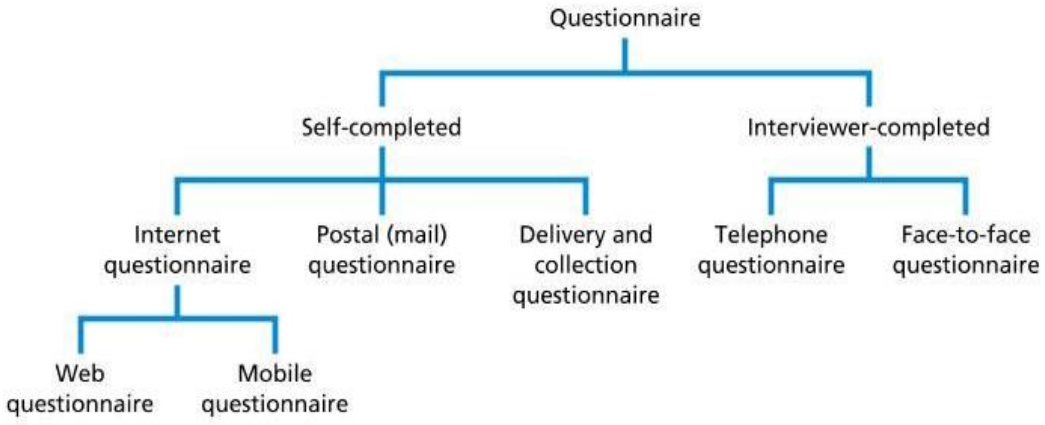

Figure 4-7: Different types of Questionnaires, (Sources: Saunders et al., 2016)

The choice of a questionnaire as the specific data collection method is appropriate as:

- It is an efficient way to seek experience and views of those involved in managing risk associated with highway construction projects across different geo-political zones in Nigeria.
- It has the ability to gather information from a large number of highway construction practitioners effectively.
- Questionnaires have often been extensively and effectively used in previous risk management studies(e.g. Wibowo & Mohamed 2010; Choudhry et al., 2014, Hwang et al., 2014)

4.8.2 Questionnaire design

A questionnaire survey was adopted for the quantitative data collected for this research. It was deemed necessary to satisfy the research objectives for this study as explained above. A questionnaire was designed based on the knowledge acquired from the literature reviews. It was designed to be relevant to meet the research objectives to satisfy the overall aim of the study and also to be in line with the type of data that the researcher intended to collect.

The finalised questionnaire for this study is presented in Appendix 1. Its first section relates to the general background information about each respondent, including their contact details, current job title/position, years of working experience in highway infrastructure construction projects, types of organisations, and knowledge about the management of risk in highway projects in Nigeria. This information will ensure that the targeted respondents have relevant experience and knowledge in the research area, which will improve the validity and reliability of the data collected.

Section two of the questionnaire was designed to satisfy the second objective of the research, which is to identify and analyse the most important risks associated with highway infrastructure construction projects in Nigeria. To ensure the validity and reliability of the data collected, as shown in figure 4-5 above, this section was designed taking into account the negative perception of risk from the Nigerian cultural setting. Nigerians view risks as a threat and not as an opportunity. It was considered that designing the questionnaire incorporating both positive and negative consequences of risk would be likely to cause confusion and would be problematic, thereby reducing the validity and reliability of the collected data. Therefore, even though the literatures reviews in the preceding chapters incorporated both negative and positive consequences of risk, it is important to note that in this research risk is being referred to as the

occurrence of uncertain events that might negatively affect the performance of highway construction infrastructure projects. For the identification of the risk factor, respondents were asked to tick from among the five options provided (very low, low, medium, high, very high) to indicate the possibility of the occurrence of 35 risk factors identified on the performance of highway infrastructure construction projects in Nigeria. Respondents were further asked to tick from among the options provided (very low, low, medium, high, very high) to indicate the consequences of occurrence (impact) of those risk on the performance of highway infrastructure construction projects in Nigeria. These questions were designed on the five point Likert scale.

Section three of the questionnaire was design to satisfy the third objective of the research which aims at investigating risk management process and techniques currently used in highway infrastructure construction project in Nigeria and their effectiveness. Respondents were asked to tick from the options (Never used, seldom used, often used, and always used) to indicate the extent of the usage of the risk management processes and techniques for the management of risk associated with highway construction infrastructure projects in Nigeria. They were further asked to tick from the options (not at all effective, slightly effective, effective, and very effective) to indicate the effectiveness of those risk management processes and techniques used in managing risks associated with highway infrastructure construction projects in Nigeria.

4.8.3 Questionnaire sampling techniques

Purpose sampling, otherwise known as the judgemental sampling technique is the most widely used of the non-probability sampling techniques, where the researcher's judgement is used to decide the most productive sample to meet the research objectives. This approach is reasonably cost-effective and it results in a high response rate, as previously explained. On the basis of this justification, the survey targets for this research were then decided to be those experts who were experienced and involved in the construction of highway infrastructure construction projects in the study area. Highway experts with practical experience in highway construction projects working in the Federal Ministry of Work and Housing (FMWH), Federal Capital Development Authority (FCDA), Federal Highway Maintenance Agency (FEMA) and Local and International contractors from Central Nigeria, South East and South West Nigeria were identified to complete the questionnaire.

4.8.4 Approaches to Questionnaire administration

After the initial design of the questionnaire, it was sent to selected highway professionals from different geo-political zones in Nigeria for pilot testing. Two representatives from each group of client, consultants and contractors of the highway infrastructure construction projects were selected in the pilot testing. Their feedback was reviewed and the questionnaire was refined before fully administering it for the main survey.

Accompanying the questionnaire was a covering letter of invitation to take part in the research project. It introduced the researcher, the research topic including the research aim and objectives. The potential participants were well informed of the confidentiality of the information that would be provided and their right to withdraw from the survey at any time if they wished to do so. The researcher's contact details were also provided, should they need any help in completing the questionnaire or any further clarifications. There are many ways in which a questionnaire can be administered, as shown in Figure 4-7, above. Self-completed questionnaires can be administered through on-line (internet based), post or through hand delivery and collection, while the interviewer-completed questionnaires can be administered either by telephone, skype, WhatsApp or through face-face (Saunders et al., 2016). Considering the context of Nigeria, a combination of these techniques was employed in distributing the questionnaire, to boost the response rate.

A web link using LimeSurvey was created to distribute some of the questionnaires using email. This was done in the following ways:

- Potential respondents already identified were reminded by emails and telephone to expect a questionnaire survey by web link through email
- Emailed the hyperlink to the questionnaire with a covering email
- The purposes of the research were summarised, including a request to participate in my survey
- A follow-up email was sent to the respondent after a week of the first email; thereafter, successive reminder emails were sent out to those yet to complete.

This approach offered the following advantages: (a) it is an effective method to reach a large number of respondents from different geo-political zones as most respondents check their emails daily; (b) it also enabled me to track those that started the survey and had not completed it, to remind them; (c) It further served as an archive where

respondents' details are stored. This allowed me to contact them for a follow-up and further invitation to participate in the interview stage; (d) there is possibility to increase response rate.

Six research assistants were recruited to help with distributing and collecting hard copy questionnaires to the highway experts (with representation from the client, contractors and consultants) directly involved in the on-going highway infrastructure construction projects in Nigeria. The research assistants themselves were highway professionals and they distributed the questionnaire during their professional meetings within the various zones. The postal system was a not suitable option as it does not work well in Nigeria. To further enhance the response rate, questionnaires were also sent though an on-line survey link (LimeSurvey), with further hand to hand distribution to the contractors, consultants and client involved in four cases of on-going highway infrastructure construction projects in central Nigeria, South East Nigeria and South West Nigeria, with the help of the trained research assistant. In all, 207 questionnaires were distributed with 128 (62%) valid responses returned. This is good compared to the 20-30% threshold response rate recommended by Fellows and Liu (2008) for construction project management research. Although Akintoye & MacLeod (1997) consider that a questionnaire could be biased if the return rate is less than 30 – 40 %, this response rate is still above both recommended thresholds.

4.8.5 Validity and reliability test

Validity and reliability tests are used to assess the quality of research in the natural sciences and quantitative research in the social sciences (Saunders et al., 2016). A piece of research is said to be reliable if the researcher is capable of replicating an earlier research design and obtains the same results. In essence, reliability denotes to replication and consistency (Lucko and Rojas, 2009). Validity denotes the appropriateness of the measures used, accuracy of the analysis of the results and generalizability of the findings (Saunders et al., 2016). Three broad types of validity are most commonly discussed in literature: (a) Measurement validity, associated with various types of validity designed to assess this intention, which include face validity, construct validity, content validity and criterion-related validity (predictive validity); (b) Internal validity and (c) External validity. With respect to a questionnaire, internal validity can be explained in terms of the ability of the questionnaire to measure what the

researcher proposes it to measure. Internal validity is sometimes referred to as measurement validity by some researchers. In most cases, researchers refer to content validity; construct validity and criterion-related validity when discussing the validity of a questionnaire. Content validity determines if the content of a study fairly represents reality. Its main concern is the extent to which a measure covers the range of meanings included within the concept. It has been established that the current research questionnaire provides sufficient coverage of the questions relating to risk factors affecting the performance of highway infrastructure construction projects and the risk management tools and techniques that meet the research objectives. This was achieved through comprehensive literature reviews and pilot testing of the questionnaire by a group of highway experts. Construct validity refers to the degree to which a set of questions truly measures the presence of a construct the researcher proposed them to measure. Criterion-related validity refers to the ability of the questions to make accurate predictions. This can be performed using statistical analysis such as correlation.

Different types of reliability exist but the most commonly noted are internal and external reliability. According to Saunders et al. (2016), internal reliability refers to ensuring consistency during a research project. This could be achieved by employing more than one researcher within a research project to conduct interviews or observations and to analyse data, to be able to evaluate the extent to which they agree about the data and its analysis, where possible. Internal reliability centres on the consistency within the measuring instrument and can be computed statistically using Cronbach's alpha ($\propto$) (Lucko and Rojas, 2009). More details of its computation are presented in section 6.2.1. External validity is all about the answer to the question: Can the study research findings be generalised to other relevant settings or groups? For example, can the findings from this current research be used to inform risk management practices in highway construction project in other developing countries?

The following precautions were taken to ensure the internal validity and reliability of the data

- The questionnaire was well designed and structured.
- The questionnaire was designed taking into account the existence of negative perception of risk from Nigerian cultural belief.

- The questionnaire was well test-piloted before actual data collection, to check for any ambiguity.
- Experts with relevant experience in the construction of highway infrastructure projects were sought for and participated in the survey.

4.9 Questionnaire data analysis methods

Different statistical tests were employed in this study for the questionnaire data analysis, which are discussed below.

4.9.1 Statistical significance tests

Basically, two main categories of statistical significance tests exist: parametric and non-parametric. Non-parametric statistics are most suitable for data that does not satisfy the normality test (i.e. data are not normally distributed) and are often used with categorised data (e.g. nominal, ordinal) while parametric statistics are suitable with numerical (continuous) data such as intervals and ratios (Bryman 2012; Saunders et al., 2016). Non-parametric tests can be used alongside parametric tests when assumptions are close to not being met. If the non-parametric matches the parametric tests, one can feel confident about using the parametric results.

4.9.2 Normality test

Normality is a description of a symmetrical pattern forming a bell shape frequency distribution (Saunders et al., 2016). The normality of data can be assessed using graphs and statistically. For a normally distributed dataset, there is the possibility of the value of the mean, median and mode being the same. The **Kolmogorov-Smirnov test and Shapiro-Wilk test** can be used to test for normality statistically. A probability, p, value of 0.05 or less in either case implies that these data are not normally distributed. Conversely, a p value greater than 0.05 implies that the data are normally distributed. The results of the **Kolmogorov-Smirnov test and Shapiro-Wilk test** in this study indicated that the entire variable in the dataset was non-normally distributed, with the p values in both cases less than 0.05 (see Appendix 2 for the results of these test for the 35 risk factors). Hence, use of a parametric test will result in misleading results and a non-parametric test is therefore considered most suitable for the analysis of the data.

4.9.3 Reliability coefficient

The reliability test is used to measure the internal consistency of the scale used. Cronbach's alpha coefficient is the most widely used in measuring the internal consistency of the scale. It is computed using the following equation:

$$\alpha = \frac{N^2.\bar{\text{Cov}}}{\sum S^2 + \sum \text{Cov}}$$

The alpha coefficient $(\propto)$, ranges between 0 and 1 with high value denoting high reliability. Saunders et al. (2016) recommend a threshold value of 0.7 and above as measuring the same things. For this research, the Cronbach alpha was found to be 0.905 which was greater than 0.7, thus indicating a high reliability of scales.

4.9.4 Mean Ranking

Mean rating is widely used in most both past and current construction project risk management studies. The mean ranking is used to measure the significance of each of the factors rated by the respondents. A meaningful mean is calculated using numerical data (Saunders et al., 2016). Hence, using numerical data, the mean rating was used to analyse the rating of risk factors and risk management techniques by different groups of respondents, such as the client, the contractors and the consultants, and for different questions.

4.9.5 Kruskal-Wallis Test

This is a non-parametric statistical significance test (one way ANOVA equivalent of a parametric test) and is used for comparing the means of variables to test the opinions of each group (i.e., the client, the government, contractors, consultants and joint ventures) regarding the importance of risk factors that affect the performance of highway infrastructure construction projects in Nigeria and the risk management tools and techniques for managing these risks (Choudhry and Iqbal, 2013). The Null hypothesis (H0) for the test is that there is no significant difference in opinion among the different groups. The decision rule is to reject the null hypothesis if p value is less than 0.05 and accept the alternative hypothesis (H1) that there is a statistical significant different in the opinion within the different groups.

4.9.6 Factor analysis

Factor analysis was applied to the 35 risk factors to assess whether these factors can be grouped under different factors and to classify them into a manageable number of

factors. This is one of the notable dimension reduction statistical techniques widely used in most construction project risk management research. The appropriateness of factor analysis was assessed by employing the Kaiser-Mayer-Olkin (KMO) test and Bartlett's test of sphericity, having investigated the reliability of the measurement using Cronbach's alpha coefficient. These are discussed in detail in Chapter 6.

4.10 Qualitative data collection methods

4.10.1 Case study methods

This research further adopted a qualitative case study in order to identify and analyse the important risks associated with highway infrastructure construction projects in Nigeria and to investigate the risk management processes and techniques currently used in highway construction projects in Nigeria and then evaluate their effectiveness, to satisfy the second and third objectives of the current research.

4.10.2 Criteria for the selection of case studies

In choosing case study for investigation, George and Bennett (2005) recommend three criteria to be considered as a rule:

- Relevant to the research objectives and questions
- Provision of diversity across contexts
- Provision of opportunity to study the complexity of the context.

Additionally, Guo et al. (2014) recommend that data accessibility is also an important criterion to consider in choosing case studies. The objective of case study for this research is to obtain an in-depth and rich understanding of risks associated with real life highway infrastructure projects in Nigeria and how they are managed. Following these recommendations by Guo et al. (2014) and George and Bennett (2005), four cases of on-going highway infrastructure construction projects were investigated. Table 4-8 presents summary information of these case studies.

Table 4- 8: Summary information of the case studies

Case studies	Span	Contract sum
Abuja-Lokoja Road Section III	49-Km span	N9.7 billion, awarded in 2006
Enugu Port Harcourt Expressway	59. 5 Km span	N39.6 billion, awarded in 2013
Lagos-Badagry Expressway	60-Km span	N100 billion, awarded in 2012
Lagos/Ibadan Express Road	127.6 km span	N170 billion, awarded in 2014

4.10.3 Justification for the use of case studies

Case study is considered appropriate for the present research on the following grounds:

- Case studies would provide an in-depth and rich understanding of risk associated with highway construction projects in Nigeria.
- Since risk management is relatively new in Nigerian highway construction projects, it is important to get a detailed and thorough view of it by investigating its use in on-going projects. A case study approach would provide an opportunity to investigate the processes to a sufficient depth and it is suitable for addressing the research objectives stated above.
- Case studies have been extensively and successfully used in risk management research to investigate risk management techniques and to improve the performance of highway construction projects, (e.g. Wang and Chou, 2003; Abednego and Ogunlana, 2006; Heravi and Hajihosseini, 2011).
- Suitable to examine contemporary real-life situations.
- Included two sources of evidence, such as direct observation and systematic interviews, which are not often included in history (Wang and Chou, 2003)

4.10.4 Design of Case study interview question

Case studies were undertaken for the qualitative aspect of data collection for this research. It was considered important to gain a deeper understanding of risks associated with highway projects in Nigeria and to expand the understanding of the risk management processes and techniques used to manage those risks and their effectiveness. A case study protocol for interview questions was designed following the same principle adopted for the questionnaire survey already discussed.

The finalised case study protocol of the interview questions for this study is presented in Appendix 4. 13 interviews were conducted with highway experts involved in the construction of 4 cases of highway projects within different locations in Nigeria using semi-structured interviews.

Semi-structured interviews are considered suitable for the following reasons:

- They allow interaction between the researcher and those involved in the highway construction project.
- They have been effectively used in previous research to obtain data from highway constructions professionals
- Information can be obtained from the interviews that will assist the researcher to compare findings from the questionnaire survey
- Interview is useful method to get richer information and is usually used in combination with other methods (Sun and Meng, 2009).
- Semi-structured and in-depth interviews can achieve a high level of validity/credibility

4.10.5 Approaches to the conduct of case study interviews

Four on-going highway infrastructure construction projects selected from Central Nigeria, South East Nigeria and South West Nigeria were selected for the case studies. Semi-structured in-depth interviews were conducted with contractors, consultants and clients with the relevant knowledge and experience to identify and analyse the important risks associated with highway infrastructure construction projects in Nigeria; and to investigate the risk management processes and techniques currently used to manage these risks. In addition to the six research assistants recruited for the questionnaire survey, four more research assistants were recruited and trained to conduct the interview. Two of them had completed their postgraduate studies in the UK and the

remaining two had completed their postgraduate studies in Nigeria and they had all also worked in the highway construction industry. All of them were involved in face to face interview supplemented by the researcher, who conducted telephone interviews with some of the participants. Telephone interview offer benefits associated with access, speed and lower cost (Saunders et al., 2016)

4.11 Data analysis of case studies interview question

The case studies interviews were analysed with the aid of the qualitative analysis software package, NVivo-11**,** using thematic analysis. Saunders et al. (2016) refer to thematic analysis as a generic approach to analysing qualitative data. Thematic analysis entails coding of qualitative data by the researcher to identify themes or pattern for further analysis pertaining to the research objectives. Thematic analysis offers a systematic but flexible and accessible approach to analyse qualitative data (Braun and Clarke, 2006). It is systematic in that it provides an organised and logical way to analyse qualitative data. It is a suitable approach for analysing large qualitative data sets as well as smaller ones resulting in richer descriptions, explanations and theory building (Saunders et al., 2016). According to Saunders et al. (2016), thematic analysis is a useful approach to:

a) comprehend often large and disparate amounts of qualitative data;
b) integrate related data drawn from different transcripts and notes;
c) identify key themes or pattern from a set of data for further exploration;
d) produce a thematic description of these data; and or
e) develop and test explanations and theories based on apparent thematic patterns or relationship;
f) draw and verify conclusions.

It is worth mentioning that thematic analysis is not tied to a particular philosophical view, which makes it a flexible approach. This means that it can be used regardless of whether an objectivist or subjectivist view or an inductive or deductive approach is being adopted. Saunders et al. (2016) outlined the procedure for carrying out thematic analysis which consists of the researcher getting familiarised with the data, coding the data, searching for themes and recognising relationships, refining themes and testing propositions.

4.12 Framework development and evaluation

The developed risk management framework (Figure 8-1) was evaluated for its application using semi-structured interviews within Nigerian highway experts. This was done to ascertain the clarity and comprehensiveness of the overall framework, and its practical relevance and suitability. The evaluation also identified potential areas of use of the framework as well as its limitations and weaknesses and the scope for future improvement.

Following the approval of the developed risk management framework by the supervisors, its full details including guidelines on the application of the framework and the mitigation measures proposed for the top nine most critical risks were sent to the Nigerian highway practitioners by email for evaluation. They were given two weeks to study and understand the framework before conducting semi-structured interview with them for the evaluation. They were contacted during the fieldwork and were reminded after the framework was ready. Out of the 25 practitioners that were contacted, 16 of them agreed to take part in the evaluation process. The highway experts involved in the evaluation process were selected from each of the four cases of large scale highway projects used as case studies. The adoption of interviews for the evaluation of the framework is necessary to provide in-depth feedback as the interviewer could clarify and extend individual items in an ad hoc semi-structured manner (Lucko and Rojas, 2009). The framework's credibility is tied to conducting the process appropriately. This will enable the potential user to have confidence in the process, even if the results were not an exact match to the objectives sought after (Mahmoud et al., 2009).

There is no specific process of how to undertake evaluation. The strongest way to establish the validity of the framework is the involvement of the subject matter experts prior to, during, after or throughout the development of the framework (Lucko and Rojas, 2009; Mahmoud et al., 2009). For example Dey (2012) used a questionnaire survey to validate a risk management framework involving key industry experts across the Indian oil industry while El-Diraby and O'Connor (2004) performed interviews with government agencies and consultants for the evaluation of their bridge plans model to establish face validity. Similarly, Love et al. (2004) conducted semi-structured interview with industry practitioners to validate their proposed supply change management model for improving the performance of the projects. Del Cano and de la Cruz (2002) used Delphi analysis approaches alongside interview with industry experts for the validation of their project risk management research. They used demographic

information such as education, position, and experience with different projects types, to support their validation process.

The evaluation revealed that the proposed risk management framework is practically relevant and considered to be suitable for the Nigerian highway infrastructure construction project and for other developing countries. However, they were in consensus that the success of its application depends on:

- Well-organized project teams to drive this through, considering the under regulated project environment in countries such as Nigeria, and involvement of project stakeholders such as the local community within which the project is situated.
- Nigeria's particular situation, including the prevalence of bad governance, corruption and lack of competency of people in positions of authority.
- The willingness of Nigerian government and industry practitioners to integrate the risk management framework into the system.

4.13 Chapter summary

The philosophical paradigm (pragmatic paradigm) under which the research was undertaken has been established in this chapter. The corresponding research strategies (mixed method strategies) and the associated specific research methods for this research were also established, together with the justification for their adoption. The methods adopted for data collection and analysis alongside their weakness and how to overcome them were also discussed. The research quality criteria concepts (validity and reliability tests) used to ensure the quality of the current research were explained

Chapter 5: Quantitative Data Analysis-Questionnaire Survey

5.1 Introduction

This chapter presents the data analysis and the findings from the questionnaire survey, which is the quantitative data analysis aspect of the research. The questionnaire is divided into three main sections (see Appendix 1): Section 1 - general background information; section 2 - Identification and analysis of risk factors; and section 3 - Risk management tools/techniques and their effectiveness. In the following sections the analysis results are presented following the structure of the questionnaire. The results regarding the risk management tools/techniques and their effectiveness with factor analysis of the risk factors are presented in Chapter Six.

5.2 General Background information (Section 1)

This section of the questionnaire covers the following items: general information about the respondents (their years of working experience in highway infrastructure construction projects, organisational types, their professions, number of highway projects they have been involved in, and the project cost); the management of highway infrastructure projects in Nigeria; procurement methods used in the delivery of highway infrastructure construction projects in Nigeria; their knowledge of risk management in highway construction projects in Nigeria; performance of highway infrastructure construction projects in Nigeria and their view regarding aspects of risk management in Nigeria. The findings are presented and discussed below.

5.3 Respondents' profiles

The general background information about the respondents is summarised in Table 5-1. Personal details, such as names of respondents, email and telephone contacts, are kept confidential, and can be used by the researcher for follow up contact where necessary. The proportions of respondents' years of working experience in highway construction projects were: 1 – 5 years (13.3%); 6-10 years (40.6%); 11-15 years (15.6%); 16 – 20 years (10.9%); ≥ 20 years (19.5%). Thus, the majority of the respondents were very experienced, 93% of them with over 5 years working experience. As shown in Table 5-1, the main organisations involved in the survey comprised: 28 Government representatives i.e. the client (Employer), 43 international contractors, 24 local contractors, 31 consultants and 2 involved in joint venture. Therefore, the largest group

is from the international contractors. This reflects the fact that the large scale highway projects in Nigeria usually involve international contractors. The main professions involved in the survey were 93 engineers, 19 quantity surveyors, 2 architects, 12 project managers, and 2 site managers. This shows that engineers made up largest proportion of these professionals involved in large scale highway projects in Nigeria, followed by substantial numbers of quantity surveyors and project managers. It can be clearly seen that the respondents had relevant professions and experience in the area of highway infrastructure construction projects. The majority of them had been involved in over 4 high value highway projects over the past three years, as seen in the table. The respondents' level of experience, professional background and their involvement in a number of highway project were considered as proof of the breadth of their expertise in the area project risk management in the Nigerian highway construction industry. Hence, it is considered that the integrity of the data can be trusted for analysis.

Table 5- 1: Respondents' profiles

Categorization		Frequency	Percentage
Years of working experience in highway projects	1 – 5	17	13.3
	6-10	52	40.6
	11-15	20	15.6
	16 - 20	14	10.9
	≥ 20	25	19.5
	Total	128	100
Organisation Type	Govt.	28	21.9
	Int'l contractor	43	33.6
	Local Contractor	24	18.8
	Consultant	31	24.2
	Joint Venture	2	1.6
	Total	128	100
Profession of respondents	Engineer	93	72.7
	Quantity Surveyor	19	14.8
	Architect	2	1.6
	Project Manager	12	9.4
	Site Manager	2	1.6
	Total	128	100
No. of highway projects involved in over the past 3 years	None	3	2.3
	1-3	57	44.6
	4-6	40	31.3
	7-10	23	18.0
	11 & above	5	3.9
	Total	128	100
Highway project cost (in billion naira) currently managed	≤ 1	6	4.7
	2-5	25	19.5
	6-10	15	11.7

11-15	16	12.5
16 - 20	21	16.4
21 - 25	39	30.5
26 & above	6	4.7
Total	128	100

5.3.1 Management of highway construction projects in Nigeria

Respondent were asked to select on the Likert Scale of 1 to 5 the statements that best described the management of highway infrastructure projects in Nigeria, where 1 = very poor; 2 = poor; 3 = fair; 4 = good; and 5 very good. The essence of this question is to understand the status of the management of highway construction projects in Nigeria. The results shown in Table 5-2 indicate that the management of highway infrastructure projects in Nigeria tends to be considered as fair. This finding suggests that there is need to improve the management of Nigerian highway infrastructure construction projects.

Table 5- 2: Management of highway infrastructure construction projects in Nigeria

Highway project risk management in Nigeria	Number	Percentage (100%)
Very poor	10	7.81
Poor	15	19.53
Fair	55	42.87
Good	32	24
Very good	6	4.69
Total	128	100

5.3.2 Assessment of the procurement methods used in the delivery of highway construction projects in Nigeria

Respondents were asked to indicate the frequency of using some selected procurement methods in the delivery of highway construction projects in Nigeria, where 1 = Never; 2 = sometimes; 3 = often; 4 = usually and 5 = always. The mean ratings shown in Table 5-3 range from 2.03 to 3.34, reflecting varying degrees of frequency of the usage of the selected procurement methods in large scale highway projects in Nigeria. The findings clearly reveal that the traditional procurement method followed by public private partnership is favoured over the other procurement routes. Additionally, the Kruskal Wallis test was performed to check whether differences in opinion regarding the selected procurement methods existed among the main organisations involved in the large scale highway projects. Table 5-3 also presents the result of the Kruskal Wallis test. The decision rule is that p value greater than 0.05 implies that there is no

significant difference in opinion between the five main organisation groups. The Kruskal Wallis test result indicated that there was no significant difference in opinion among the 5 main organisations, with the exception of design and build procurement methods. More detailed analysis revealed that the design and build procurement method had been given highest rating by international contractors and lowest rating by joint ventures, with mean rank of 43 and 2 respectively (Appendix 3). This is an insignificant difference of opinion, as the joint ventures were not the majority of the main organisations and there were only two of them out 128. The result is consistent with the findings of Dada and Jagboro (2007) that tradition procurement methods are well favoured in the Nigerian construction industry. Traditional procurement methods are mostly used in the delivery of most public infrastructure projects in developing countries

Table 5- 3: Kruskal Wallis test of the frequency of the procurement in the delivery of highway construction projects in Nigeria

Procurement methods	Mean	Ranking	Kruskal Wallis test Chi-Square (x^2)	Sig P.
Traditional	3.34	1	8.939	0.063
Design and Build	2.39	3	11.178	0.025
Management Contracting	2.03	5	9.531	0.049
Construction Management	2.34	4	7.9	0.095
Public Private Partnerships (PPP)	2.48	2	2.712	0.607

5.3.3 Assessment of Nigerian highway professionals' knowledge of project risk management

This section of general background information relates to the respondents' general knowledge of project risk management. The respondents were required to choose from the options that best rate their knowledge of risk management in highway infrastructure construction projects, using a Likert scale of 1 – 5, where 1 = very poor, 2 = poor; 3 = fair; 4 = good and 5 = very good. The results for the mean rating shown in Table 5-4 range from 3.50 to 3.63, indicating the varying degrees of Nigerian highway professionals' knowledge of project risk management. The overall mean rating of 3.59 confirms that the Nigerian highway professionals had a good knowledge of project risk management. To ascertain if there were any significant differences in opinion among the 5 main groups of the organisation involved in the survey, the Kruskal Wallis test

was performed (Table 5-4). Applying the same decision rule as in section 5.1.3, the results indicate that there is no significant difference among the 5 main groups regarding the highway professionals' knowledge of project risk management, as p value of 0.808 is greater than 0.05. Therefore, there was no need to perform further test. This further strengthens the likelihood that their opinion regarding risk management in highway construction projects will be credible.

Table 5- 4: Highway professionals' knowledge of project risk management

Category	Govt.	Int'l contr.	Local contr.	Consultant	JV	Overall	Kruskal Wallis test	
Mean	3.54	3.63	3.5	3.68	3	3.59	x^2	Sig. p
							1.605	0.808
N	28	43	24	31	2	128		

5.3.4 Performance of highway construction projects in Nigeria

The essence of this section of general background information is to understand the current performance of highway infrastructure construction projects in Nigeria. To achieve this, respondents were asked to choose from the options provided to rate the performance of highway infrastructure construction projects in Nigeria against the performance criteria (timely completion, cost, quality, environmental sustainability and stakeholder management) on the Likert scale of 1 – 5 where 1 = very poor; 2 = poor; 3 = fair; 4 = good; and 5 = very good. The overall mean ratings shown in Table 5-5 range from 2.18 to 3.49, indicating varying degrees of performance of highway infrastructure construction projects in Nigeria.

It can be seen that the overall performance of highway infrastructure construction projects in Nigeria based on the stated criteria are not very good, except for quality that is approximately good. This is not surprising as it has been reported in Chapter Two that the performance of highway construction projects in developing countries is very poor, particularly in Sub Saharan Africa, compared to that of their counterparts elsewhere. To verify the perceptions of the main group of the organisations involved in the survey, the Kruskal Wallis test was performed, which confirmed that the clients, contractors and consultants shared the same perception about the performance of highway infrastructure construction projects in Nigeria, since the significance value p is greater than 0.05. Since there was no significant difference in the perceptions among the

main groups, it was not deemed necessary to perform further tests. This finding establishes the need to develop a risk management framework to improve the performance of large scale highway construction projects in Nigeria.

Table 5- 5: Performance of highway construction projects in Nigeria

Performance criteria	Govt.	Int'l Contr.	Local contr.	Consul.	Joint Ven.	Overall	Kruskal Wallis Test	
							x^2	Sig. p
Timely completion	2.11	2.07	2.37	2.26	2	2.18	2.393	0.664
Within budget	2.54	2.47	2.29	2.52	2.5	2.46	1.463	0.833
Quality	3.75	3.4	3.46	3.45	3	3.49	4.946	0.293
Env. sustainability	3.36	3.05	3	3.03	3	3.1	2.554	0.635
Stakeholder mgt.	3.14	2.84	2.67	3.13	3	2.95	3.907	0.419

5.3.5 Project risk management in Nigeria

To further investigate the current state of risk management in Nigeria, respondents were asked to indicate their opinion on the related statement on the Likert scale of 1 to 5 where 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; & 5 = strongly agree. The results for each statement are shown in Table 5-6. For further details on the questionnaire responses, see Appendix 1. The (a) part of the statement aims at establishing if there is no formal requirement for the management of risks in Nigerian highway construction industries. From the overall mean rating of 2.58 (table 5-6), the finding tended toward disagreeing with the statement that there is no formal requirement for the management of risks in Nigerian highway construction industries. To ascertain whether there was a discrepancy in opinion among the five main participants of the survey, a Kruskal Wallis test was performed and the analysis suggested that there was no discrepancy in opinion among the key groups that participated in the questionnaire survey. This may suggest that there is certainly a requirement for the management of risk but the issues lie with the implementation.

Table 5- 6: Project risk management in the Nigerian highway projects

Question code	Govt.	Int'l contr.	Local contr.	Consul	JV		Kruskal Wallis Test	
	Mean	Mean	Mean	Mean	Mean	Overall rating	x^2	Sig. p
a	2.39	2.53	2.83	2.58	3	2.58	2.195	0.7
b	3.82	3.53	3.92	4	3	3.77	6.812	.146
c	4.21	4.09	4.46	4.45	4	4.27	2.986	0.56
d	4.46	3.42	4.08	3.65	3.50	3.83	5.557	0.235
e	3.39	3.77	4	3.61	3	3.68	6.069	0.194
f	2.61	2.33	2.29	2.32	2	2.37	1.462	0.833

Where a = There is no formal requirement for the management of risks in Nigerian highway construction industries; b = There is high demand for professional risk management skills development among construction experts in Nigeria; c = Managers' proficiency in risk management plays a crucial role in project risk management; d = Risk management will attract substantial extra cost of management expenses and time; e = Project risk management in Nigerian highway construction projects is often dealt with inadequately; f = Satisfaction with the way highway construction infrastructure projects are being managed in Nigeria.

The (b) part of the statement, 'There is high demand for professional risk management skills development among construction experts in Nigeria,' was intended to provide information on the need for the Nigerian highway experts' risk management skills. The overall mean rating of 3.77 suggest that there is need for professional risk management skills development among construction experts in Nigeria. This finding is a reflection of the fact that for risk management to be effective, it is essential that professionals should improve their risk management skills. The result of the Kruskal Wallis test, p value 0.146, (Table 5.6) further shows that there is no significant difference in the perception among the main group of the participant represented. Therefore, for effective implementation of risk management practices in the Nigerian highway construction industries, it is agreed that there is need for the experts to develop their risk management skills.

In response to the (c) part of the statement: 'Managers' proficiency in risk management plays a crucial role in project risk management', the overall mean ranking of 4.27 (Table 5-6) demonstrates that the respondents regarded managers' proficiency in risk management as playing a crucial role in project risk management. This indicates that managers in charge of highway construction projects should be competent in project risk management. This in turn will enhance the success of project risk management. The Kruskal Wallis test was performed to verify if there was any significant difference in opinion among the main groups of the participants; the significance value of 0.56

shows that there was no discrepancy in opinion among the main groups, as shown in Table 5-6.

In the response to the (d) part of the statement: 'Risk management will attract substantial extra cost of management expenses and time,' the overall mean ranking of 3.88 (Table 5-6) showed that the respondents tended to agree with the statement. To ascertain whether there was any discrepancy in opinion among the five main participants of the survey, the Kruskal Wallis test was performed. The significant test value of 0.235 implied that there was a consensus among the respondents that risk management is expensive and time consuming. This may be suggested as one of the reasons why project risk management in Nigerian highway construction projects is often dealt with inadequately, as reported in the next paragraph.

The (e) part of the statement aimed at establishing whether the respondents considered that project risk management in Nigerian highway construction projects is often dealt with inadequately. The overall mean ranking of 3.68 (Table 5-6) implies that project risk management in these projects is often dealt with inadequately. The Kruskal Wallis test was performed to see if there were differences in opinion among the main participants; the significance value of 0.194 indicated that there was a consensus among the respondents that project risk management in the Nigerian highway construction infrastructure projects is often dealt with inadequately. This could account for the poor performance of highway construction projects in Nigeria. Therefore, the need for the improvement of risk management in the Nigerian highway construction industries cannot be overemphasized.

The (f) part of the question aimed to establish whether the Nigerian experts were satisfied with the way highway infrastructure construction projects are being managed in Nigeria. The overall mean ranking of 2.37 (Table 5-6) shows that they were dissatisfied with the management of highway infrastructure construction projects in Nigeria. The result of the Kruskal Wallis test of p value 0.833 (Table 5-6) indicates that there was consensus among the main groups of participants that they were not satisfied with the way large scale highway projects were being managed. This finding, alongside the findings presented in Tables 5-2 to 5-5 calls for a need to develop a comprehensive risk management framework for the management of highway infrastructure construction projects in Nigeria.

5.4 Identification & analysis of risk factors affecting the performance of highway infrastructure construction projects in Nigeria (Section 2)

As discussed in Chapter 3, section 3.1.8; 35 risk factors were identified from the literature and classified into two main categorizations (external and internal risk factors). These were further sub-divided into risk factor level and risk sub-factors level, as shown Table 3-3 (Chapter 3), adopting the classification of Bing et al., 2005. The question under this section is in two parts. In the first part of the question, respondents were requested to indicate among the 35 risk factors the possibility of their occurrence in the performance of highway infrastructure construction projects in Nigeria, using the Likert scale of 1 – 5 where 1 = very low; 2 = low; 3 = medium; 4 = high; and 5 = very high. The second part of the question required the respondents to rate the consequences (impact) of each of the 35 risk factors on the performance of these construction projects, using the same Likert scale as in the first part of the question. A copy of the question can be seen in Appendix 1. The results of the possibility of occurrence of the risk factors and their corresponding consequences (impacts) will be used in computing the risk criticality, to determine the most important risk factors affecting the performance of highway construction infrastructure projects in Nigeria. Because assessment of risk criticality is complex and vague, qualitative descriptive terms cannot be avoided (Wang et al., 2004). Therefore, five-point Likert scales were adopted (see Table 5-7). The possibility of occurrence (PO) and the Consequence of occurrence (CO) of each risk can be calculated using equations 5.1 and 5.2 respectively.

$$PO^i = \frac{1}{n}\sum_{j=1}^{n} PO_j^i \quad \text{.....Equation 5.1}$$

$$CO^i = \frac{1}{n}\sum_{j=1}^{n} CO_j^i \quad \text{.....Equation 5.2}$$

Where n = number of respondents; PO^i = Possibility of occurrence of risk *i*; PO_j^i= possibility of occurrence of risk *i* by respondent j; CO^i= Consequence of occurrence of risk *i* by respondent *j*. Hence, the PO and CO of each risk are the mean rankings ranked by the respondent.

Table 5- 7: Likert scales for PO & CO, (Source: Zhao et al., 2013)

Possibility of occurrence			Consequence of occurrence	
PO	Descriptive terms	Possibility reference (%)	CO	Descriptive terms
0	Unidentified risk	< 20		
1	Very low (rarely)	20 – 30	1	Very low
2	Low (somewhat likely)	30 – 35	2	Low
3	Medium (likely)	45– 50	3	Medium
4	High (very likely	50– 70	4	High
5	Very High (almost certain)	> 70	5	Very high

The risk criticality index (RC) is adopted in this research to calculate the criticality of each of the 35 risk factors. RC has been widely acknowledged as the function of PO and CO (e.g. Zayed et al., 2008; Zhao et al., 2013; Zou et al., 2007). Therefore, the RC of the risk can be calculated using the following formulae:

$RC_j^i = PO_j^i \times CO_j^i$ ……Equation 5.3

$RC^I = \frac{1}{n}\sum_{j=1}^{n} RC_j^i$ ……Equation 5.4

Where n denotes the number of respondents RC_j^i, the risk criticality of the respondent *I* by respondent *j*; and RC^I = the risk criticality of risk *i*. Hence, the RC is on a full scale of 25.

The data collected from the 128 highway experts were analysed using IBM SPSS statistics version 22.

5.5 Identification of major risk factors affecting the performance of highway infrastructure construction projects in Nigeria

The overall rating of the possibility of occurrence of the risk factors is shown in Table 5-8. The Kruskal-Wallis test was also computed for the comparison of means of variables to test the views of each of the groups (the representing the government, consultants, contractors and joint ventures) about the possibility of occurrence of each of the 35 risk factors, as shown in Table 5-9. For the Kruskal-Wallis test, a p value less than 0.05 implies that there is a statistically significant difference in views or perceptions regarding the possibility of occurrence of risk factors among the different groups.

Table 5- 8: Possibilities of occurrence of risk factors affecting the performance of highway construction projects in Nigeria

Risk factor Coding	Risk type	Risk factor description	Overall rating (PO)	R	Kruskal Wallis Test x^2	Sig. p
HRI 20	Internal	Project funding challenge	3.98	1	10.938	0.027**
HRI 21	Internal	Construction time delay	3.96	2	4.762	0.313
HRI 3	External	Political interference	3.83	3	2.224	0.695
HRI 6	External	Exchange rate fluctuation	3.81	4	2.075	0.722
HRI 7	External	Inflation/interest rate fluctuation	3.79	5	3.762	0.439
HRI 5	External	Government officials demand bribe /unjust reward	3.66	6	17.505	0.002**
HRI 22	Internal	Construction cost overrun	3.66	7	3.45	0.486
HRI 2	External	Project being cancelled due to change in ruling party	3.56	8	1.299	0.862
HRI 1	External	Unstable government	3.55	9	4.174	0.383
HRI 35	Internal	Lack of joint risk mechanism by parties	3.27	10	7.271	0.122
HRI 17	External	Weak regulatory & monitoring regime	3.22	11	3.141	0.534
HRI 26	Internal	High maintenance cost	3.2	12	2.255	0.689
HRI 28	Internal	Lack of quality control and monitoring	3	13	5.157	0.272
HRI 29	Internal	Subcontractors' incompetence	2.95	14	7.712	0.103
HRI 34	Internal	Lack of commitment between parties	2.95	15	8.158	0.086
HRI 11	External	Land acquisition and compensation problems	2.93	16	1.019	0.907
HRI 25	Internal	Inappropriate procurement methods	2.91	17	4.92	0.296
HRI 27	Internal	Poor communication within different parties	2.91	18	6.43	0.169
HRI 23	Internal	Defective design, error and rework	2.9	19	1.737	0.784
HRI 9	External	Poor relationship with community	2.84	20	9.411	0.052
HRI 14	External	Terrorism attack	2.8	21	2.728	0.604
HRI 12	External	Inclement weather	2.77	22	1.169	0.883
HRI 18	External	Unavailability of special equipment	2.77	23	2.995	0.559
HRI 16	External	Lack of legal regulatory framework	2.76	24	3.598	0.463
HRI 4	External	Expropriation /Nationalization	2.71	25	3.438	0.487
HRI 13	External	Adverse ground conditions	2.7	26	3.824	0.43
HRI 24	Internal	Availability of design details	2.7	27	2.314	0.678
HRI 19	External	Failure of major constr. equipment & unavailability of spare parts	2.66	28	2.52	0.641
HRI 15	External	Flood	2.59	29	2.438	0.656
HRI 30	Internal	Poor competence of workers	2.58	30	1.674	0.795
HRI 31	Internal	Shortage of experts in highways	2.5	31	4.304	0.366
HRI 32	Internal	Shortage of skilled workers	2.48	32	4.411	0.353
HRI 10	External	Landowner unwilling to sell	2.4	33	1.717	0.788
HRI 8	External	Level of public opposition to projects	2.38	34	2.766	0.598
HRI 33	Internal	Shortage/unavailability of materials	2.38	35	1.256	0.869

** There are statistically significant differences of opinion within the groups

Table 5- 9: Rating of the possibilities of the occurrence of risk factors affecting the performance of highway construction projects in Nigeria by different groups

Risk code	Risk type	Government		Int'l Contractor		Local contractor		Consultant		Joint venture		Overall		Kruskal Wallis Test	
		PO	Rank	PO	Rank	PO	Rank	PO	Rank	PO	Rank	PO	Rank	x^2	Sig. p
HRI 1	External	3.89	3	3.44	10	3.58	9	3.42	10	2.5	19	3.55	9	4.174	0.383
HRI 2	External	3.61	8	3.56	8	3.67	7	3.48	9	3	11	3.56	8	1.299	0.862
HRI 3	External	3.89	4	3.93	4	3.75	4	3.71	4	3.5	5	3.83	3	2.224	0.695
HRI 4	External	2.68	25	2.88	18	2.63	21	2.55	31	3	12	2.71	25	3.438	0.487
HRI 5	External	2.86	16	4.07	1	3.92	2	3.61	6	4	1	3.66	6	17.505	0.002**
HRI 6	External	3.71	6	3.91	6	3.75	5	3.84	1	3.5	6	3.81	4	2.075	0.722
HRI 7	External	3.79	5	3.98	2	3.71	6	3.58	7	4	2	3.79	5	3.762	0.439
HRI 8	External	2.61	28	2.4	35	2.29	32	2.26	34	2	29	2.38	34	2.766	0.598
HRI 9	External	2.61	29	3.16	13	2.54	26	2.81	19	3.5	7	2.84	20	9.411	0.052
HRI 10	External	2.46	32	2.44	34	2.5	28	2.23	35	2	30	2.4	33	1.717	0.788
HRI 11	External	2.89	14	3	16	2.96	14	2.87	18	2.5	20	2.93	16	1.019	0.907
HRI 12	External	2.79	22	2.81	22	2.63	22	2.77	22	3	13	2.77	22	1.169	0.883
HRI 13	External	2.96	13	2.65	26	2.62	24	2.65	27	2	31	2.7	26	3.824	0.43
HRI 14	External	2.86	17	2.72	24	2.96	15	2.65	28	4	3	2.8	21	2.728	0.604
HRI 15	External	2.79	23	2.63	30	2.33	31	2.55	32	2.5	21	2.59	29	2.438	0.656
HRI 16	External	2.68	26	2.65	27	2.79	20	2.97	17	2.5	22	2.76	24	3.598	0.463
HRI 17	External	3.18	9	3.4	11	3.04	12	3.13	15	3.5	8	3.22	11	3.141	0.534
HRI 18	External	2.86	18	2.84	21	2.46	30	2.81	20	3	14	2.77	23	2.995	0.559
HRI 19	External	2.61	30	2.51	32	2.83	19	2.71	24	3.5	9	2.66	28	2.52	0.641
HRI 20	Internal	4.32	1	3.93	5	4.08	1	3.77	3	2.5	23	3.98	1	10.938	0.027**
HRI 21	Internal	4.18	2	3.98	3	3.92	3	3.84	2	3	15	3.96	2	4.762	0.313
HRI 22	Internal	3.71	7	3.67	7	3.63	8	3.68	5	2.5	24	3.66	7	3.45	0.486
HRI 23	Internal	3.11	10	2.88	19	2.88	17	2.74	23	3	16	2.9	19	1.737	0.784
HRI 24	Internal	2.71	24	2.81	23	2.58	25	2.68	26	2	32	2.7	27	2.314	0.678
HRI 25	Internal	2.86	19	2.88	20	3.21	11	2.81	21	2	33	2.91	17	4.92	0.296
HRI 26	Internal	3.04	11	3.14	14	3.29	10	3.35	11	3	17	3.2	12	2.255	0.689
HRI 27	Internal	2.86	20	2.72	25	2.88	18	3.23	13	3.5	10	2.91	18	6.43	0.169

HRI 28	Internal	2.68	27	3.05	15	3	13	3.16	14	4	4	3	13	5.157	0.272
HRI 29	Internal	2.82	21	2.93	17	2.63	23	3.35	12	2.5	25	2.95	14	7.712	0.103
HRI 30	Internal	2.54	31	2.65	28	2.5	29	2.61	30	2	34	2.58	30	1.674	0.795
HRI 31	Internal	2.32	34	2.58	31	2.29	33	2.71	25	2.5	26	2.5	31	4.304	0.366
HRI 32	Internal	2.29	35	2.65	29	2.17	34	2.65	29	3	18	2.48	32	4.411	0.353
HRI 33	Internal	2.39	33	2.49	33	2.17	35	2.39	33	2.5	27	2.38	35	1.256	0.869
HRI 34	Internal	2.89	15	3.19	12	2.54	27	3.03	16	2	35	2.95	15	8.158	0.086
HRI 35	Internal	3	12	3.47	9	2.96	16	3.52	8	2.5	28	3.27	10	7.271	0.122

**There are statistically significant differences of opinion between the groups

Note that in case of equal mean, ranking is based on the code order (Adopted from Wibowo and Mohamed, 2010)

The overall rankings of the possibility of occurrence of risk factors based on their means are shown in Table 5-8. Government, international contractors, local contractors, consultants and joint venture participants shared the same opinions on 32 of the 35 risks but differ on the remaining 2 risks as revealed by the Kruskal-Wallis test. Their opinions are differed significantly regarding project funding challenges and corrupt government officials demanding bribes/unjust rewards ($p < 0.05$) for which p is 0.027 and 0.002 respectively. Further analysis shows that project funding challenge has been given relatively low rankings by the joint venture participants (Table 5-9). Apart from that, it was ranked first by both the government and local contractors and third by the consultants. It should be noted that the joint venture group only comprised 2 out of 128 respondents. The results of further analysis also show that corrupt government officials demanding bribes/unjust rewards has been given relatively low ranking by the government representatives. This is not surprising as this risk is government related. Hence, it would be difficult for the government officials to comment on this factor for confidentiality reasons. However, the results of the in-depth interviews presented in the next chapter confirmed that corruption is a risk of serious concerned affecting the performance of highway construction infrastructure projects in Nigeria.

In all, the nine most important risks that were perceived to have a high possibility of occurrence are project funding change (Mean = 3.98; Rank = 1st); construction time delay (Mean = 3.96; Rank = 2nd); political interference (Mean = 3.83; Rank = 3rd); exchange rate fluctuation (Mean = 3.81; Rank = 4$^{th);}$ inflation/interest rate fluctuation (Mean = 3.79; Rank = 5th); Government official demand bribe/unjust reward (Mean = 3.66; Rank = 6th); construction cost overrun (Mean = 3.66; Rank = 7th); project being cancelled due to change in ruling party (Mean = 3.56; Rank = 8th); unstable government (Mean = 3.56; Rank = 9th).

With reference to Table 5-7, it can be seen that no risk has PO value above 4.00, implying that these nine factors did occur in highway construction infrastructure projects in Nigeria, with the possibility of occurrence between (50–70) percent. Furthermore, no risk has PO value less than 2.00, implying that there is no identified risk that has possibility of occurrence (< 20) percent.

5.5.1 Investigation of the consequences (impacts) of occurrences of risk factors on the performance of highway infrastructure construction projects in Nigeria

The results of the consequences (impact) of each of the 35 risk factors on the performance of highway infrastructure construction projects in Nigeria are shown in Tables 5-10 and 5-11 respectively. Table 5-10 shows the result of the overall rankings while Table 5-11 shows the rankings of the consequences of those risk factors by different groups (government, international contractors, local contractors, consultants and joint venture) just as in section 5.2.1.

Table 5-10: Consequences (impacts) of occurrences of risk factors on the performance of highway construction infrastructure projects in Nigeria

Risk factor Coding	Risk type	Risk factors description	Overall rating		Kruskal Wallis Test	
			CO	R	x^2	Sig. p
HRC 20	Internal	Project funding challenge	3.92	1	5.979	0.201
HRC 3	External	Political interference	3.86	2	1.373	0.849
HRC 6	External	Exchange rate fluctuation	3.83	3	9.471	0.05
HRC 22	Internal	Construction cost overrun	3.8	4	8.155	0.086
HRC 1	External	Unstable government	3.77	5	5.945	0.203
HRC 21	Internal	Construction time delay	3.76	6	3.248	0.517
HRC 7	External	Inflation/interest rate fluctuation	3.75	7	7.841	0.098
HRC 5	External	Government officials demand bribe /unjust reward	3.7	8	12.106	0.017**
HRC 2	External	Project being cancelled due to change in ruling party	3.64	9	4.922	0.295
HRC 28	Internal	Lack of quality control and monitoring	3.27	10	16.803	0.002**
HRC 35	Internal	Lack of joint risk mechanism by parties	3.27	11	11.346	0.023**
HRC 26	Internal	High maintenance cost	3.26	12	10.436	0.034**
HRC 17	External	Weak regulatory & monitoring regime	3.24	13	4.421	0.352
HRC 23	Internal	Defective design, error and rework	3.23	14	9.589	0.048
HRC 34	Internal	Lack of commitment between parties	3.21	15	16.09	0.003**
HRC 14	External	Terrorism attack	3.16	16	1.205	0.877
HRC 24	Internal	Availability of design details	3.1	17	5.35	0.253
HRC 27	Internal	Poor communication within different parties	3.05	18	13	0.011**
HRC 25	Internal	Inappropriate procurement methods	2.98	19	2.961	0.564
HRC 11	External	Land acquisition and compensation problems	2.92	20	3.455	0.485
HRC 9	External	Poor relationship with community	2.9	21	6.928	0.14
HRC 29	Internal	Subcontractors' incompetence	2.9	22	18.051	0.001**
HRC 15	External	Flood	2.88	23	6.84	0.145
HRC 32	Internal	Shortage of skilled workers	2.88	24	18.067	0.001**
HRC 16	External	Lack of legal regulatory framework	2.86	25	9.942	0.041**
HRC 4	External	Expropriation /Nationalization	2.85	26	2.408	0.661
HRC 12	External	Inclement weather	2.84	27	6.192	0.185
HRC 18	External	Unavailability of special equipment	2.84	28	1.747	0.782
HRC 19	External	Failure of major constr. equipment & Unavailability of spare parts	2.84	29	4.791	0.309
HRC 33	Internal	Shortage/unavailability of materials	2.81	30	14.415	0.006**
HRC 13	External	Adverse ground conditions	2.74	31	4.405	0.354
HRC 31	Internal	Shortage of experts in highways	2.66	32	8.778	0.067
HRC 30	Internal	Poor competence of workers	2.61	33	3.305	0.508
HRC 8	External	Level of public opposition to projects	2.55	34	0.643	0.958
HRC 10	External	Landowner unwilling to sell	2.41	35	2.645	0.619

** There are statistically significant differences of opinion within the groups

The overall rankings of the consequences of occurrence risk factors based on their means are as shown in Table 5-10. It can be seen that government officials, international contractors, local contractors, consultants and representatives of joint ventures shared the same opinions on 25 out of the 35 risks but differed on the remaining 10 risks, as revealed by the Kruskal-Wallis test. Their opinions regarding the consequences of the occurrence of the identified risks were significantly different with respect to government officials demanding bribes or unjust rewards ($p = 0.017$); lack of quality control and monitoring ($p = 0.002$); lack of joint risk management mechanism by parties ($p = 0.023$); high maintenance cost ($P = 0.034$); lack of commitment between parties ($p = 0.003$); poor communication within different parties ($p = 0.011$); sub-contractors' incompetence ($p = 0.001$); shortage of skilled workers ($p = 0.001$); lack of legal regulatory framework ($p = 0.041$); and shortage/ unavailability of material ($p = 0.006$). Further analysis as shown in Table 5-11 revealed that the consequences of corrupt government officials demanding bribes/unjust rewards being relatively ranked low by the government implies that they did not agree that it would have major consequences on the performance of highway projects. Nevertheless, on an individual group basis there is consensus that corruption will have considerable consequences on the performance of highway construction projects, as revealed in Table 5-11. Lack of quality control and monitoring was given relatively high ranking by participants from joint ventures, international contractors and consultants but a relatively low ranking by local contractors and government. Lack of quality control and monitoring was of serious concern by these groups of respondents mainly because the responsibilities lie with them. Lack of joint risk management mechanisms was ranked high by consultants but low by the joint venture participants. High maintenance cost was give high rankings by those from the joint ventures but ranked relatively low by the remaining groups. Other details for differences in opinion regarding the consequences of the occurrence of risk factors can be seen in Table 5-11.

Overall, the results reveal that the top nine risk factors that were regarded as most likely to have major consequences (50 - 70) percent on the performance of highway infrastructure construction projects in Nigeria were: Project funding challenge (Mean = 3.92; Rank = 1^{st}); Political interference (Mean = 3.86; Rank = 2^{nd}); Exchange rate fluctuations (Mean = 3.83; Rank = 3^{rd}); Construction cost overrun (Mean = 3.80; Rank = 4^{th}); Unstable government (Mean = 3.77; Rank = 5^{th}); Construction time delay (Mean = 3.76; Rank = 6^{th}); Inflation/Interest rate fluctuation (Mean = 3.75; Rank = 7^{th});

Government official demand bribe/unjust reward (Mean = 3.70; Rank =8th) and Project being cancelled due to change in ruling party (Mean = 3.64; Rank = 9th). The Kruskal-Wallis test revealed that there was statistically significant agreement in opinions among all the groups (Government, International contractors, Local contractors, and Joint venture) regarding the high consequences of the top nine risks, except for government officials demand bribe/unjust reward which has been explained previously. Nine risks had CO rankings above 3.50 implying that they were seen to have relatively severe consequences on the performance of highway construction projects in Nigeria.

Table 5-11: Rating of the consequences of occurrences of risk factors on the performance of highway infrastructure construction projects in Nigeria by different groups

Risk code	Risk type	Government		Int'l Contractor		Local contractor		Consultant		Joint venture		Overall		Kruskal Wallis Test	
		CO	Rank	CO	Rank	CO	Rank	CO	Rank	CO	Rank	CO	Rank	x^2	Sig. p
HRC 1	External	3.89	3	4	4	3.46	6	3.65	10	3	22	3.77	5	5.945	0.203
HRC 2	External	3.32	9	3.81	8	3.67	3	3.68	8	3.5	11	3.64	9	4.922	0.295
HRC 3	External	3.93	2	3.86	7	3.71	2	3.9	2	4	1	3.86	2	1.373	0.849
HRC 4	External	2.71	28	2.93	25	2.71	16	2.97	28	3	23	2.85	26	2.408	0.661
HRC 5	External	3.11	12	3.88	6	3.75	1	3.94	1	3.5	12	3.7	8	12.106	0.017**
HRC 6	External	3.68	7	4.09	2	3.5	4	3.9	3	3	24	3.83	3	9.471	0.05
HRC 7	External	3.71	6	4.02	3	3.38	8	3.71	7	3.5	13	3.75	7	7.841	0.098
HRC 8	External	2.54	33	2.56	34	2.42	28	2.65	34	2.5	33	2.55	34	0.643	0.958
HRC 9	External	2.89	23	3	23	2.46	25	3.1	23	3	25	2.9	21	6.928	0.14
HRC 10	External	2.57	32	2.3	35	2.25	31	2.48	35	3	26	2.41	35	2.645	0.619
HRC 11	External	2.93	21	2.86	27	2.67	19	3.19	20	3	27	2.92	20	3.455	0.485
HRC 12	External	3.21	10	2.74	30	2.62	22	2.81	31	3	28	2.84	27	6.192	0.185
HRC 13	External	2.96	17	2.65	33	2.58	23	2.74	33	3.5	14	2.74	31	4.405	0.354
HRC 14	External	3.07	13	3.23	18	3	10	3.23	18	3.5	15	3.16	16	1.205	0.877
HRC 15	External	3.07	14	2.86	28	2.42	29	3.06	25	3.5	16	2.88	23	6.84	0.145
HRC 16	External	2.86	24	3.07	20	2.46	26	2.81	32	4	2	2.86	25	9.942	0.041**
HRC 17	External	3.18	11	3.47	12	2.96	11	3.19	21	3.5	17	3.24	13	4.421	0.352
HRC 18	External	2.86	25	2.93	26	2.63	20	2.84	29	3	29	2.84	28	1.747	0.782
HRC 19	External	3.04	15	2.84	29	2.46	27	3	27	2.5	34	2.84	29	4.791	0.309
HRC 20	Internal	4.07	1	4.14	1	3.5	5	3.81	5	4	3	3.92	1	5.979	0.201
HRC 21	Internal	3.89	4	3.81	9	3.42	7	3.81	6	4	4	3.76	6	3.248	0.517
HRC 22	Internal	3.82	5	3.98	5	3.33	9	3.9	4	4	5	3.8	4	8.155	0.086
HRC 23	Internal	3.36	8	3.47	13	2.58	24	3.29	16	3.5	18	3.23	14	9.589	0.048
HRC 24	Internal	2.96	18	3.3	16	2.83	14	3.1	24	4	6	3.1	17	5.35	0.253
HRC 25	Internal	2.93	22	3.02	22	2.75	15	3.13	22	3.5	19	2.98	19	2.961	0.564
HRC 26	Internal	2.96	19	3.33	14	2.96	12	3.61	11	4	7	3.26	12	10.436	0.034**
HRC 27	Internal	2.79	27	3.28	17	2.63	21	3.23	19	4	8	3.05	18	13	0.011**
HRC 28	Internal	2.96	20	3.56	10	2.71	17	3.55	12	4	9	3.27	10	16.803	0.002**
HRC 29	Internal	2.61	30	3.12	19	2.25	32	3.35	15	3	30	2.9	22	18.051	0.001**
HRC 30	Internal	2.46	35	2.67	32	2.38	30	2.84	30	3	31	2.61	33	3.305	0.508

HRC 31	Internal	2.54	34	2.72	31	2.17	34	3.03	26	3	32	2.66	32	8.778	0.067
HRC 32	Internal	2.61	31	3.05	21	2.21	33	3.42	14	3.5	20	2.88	24	18.067	0.001**
HRC 33	Internal	2.64	29	2.95	24	2.12	35	3.26	17	4	10	2.81	30	14.415	0.006**
HRC 34	Internal	2.86	26	3.51	11	2.71	18	3.45	13	3.5	21	3.21	15	16.09	0.003**
HRC 35	Internal	3	16	3.33	15	2.92	13	3.68	9	2.5	35	3.27	11	11.346	0.023**

**There are statistically significant differences of opinion within the groups.

Note that in the case of equal means, ranking is based on the code order (Adopted from Wibowo and Mohamed, 2010)

5.5.2 Criticality of the identified Nigerian highway project risk

Attempting to identify and consider all the risks associated with Nigerian highway construction projects would clearly be time consuming, an exercise in futility and would result in failure. Thus it is logical to identify only the most critical risks and control them. Therefore, it very important to identify the most important risks affecting the performance of highway construction projects in Nigeria and effectively manages them. The criticality of the identified risks can be calculated using equations 5.3 and 5.4. The rankings of the risks were based on their overall possibility of occurrence and their corresponding consequences. Based on these, the criticality index was computed and the results are shown in Table 5-13, using the threshold for the assessment of the criticality of the identified risks shown in Table 5-12.

Table 5-12: Threshold of the criticality of the identified Nigerian highway project risk (Source: Mojtahedi et al., 2010)

Identified risks	C1	Criticality level
Very high risk (almost certain	> 0.7	Most critical
Highly possible risk	0.50 – 0.70	More critical
possible risk	0.45 – 0.50	Somewhat Critical
Low risk	0.35 – 0.45	Less critical
Very low risk	0.20 – 0.35	Least critical (rarely critical)
Unidentified risk	< 0.20	

From Table 5-13, three categories of risks were identified out of the 35 risks (more critical, less critical and rarely critical). None was found to be very highly critical or somewhat critical. Nine risks were identified to be highly or more critical which falls within the threshold band of (0.50 – 0.70); eight to be less critical (0.35 – 0.45) and eighteen to be rarely critical (0.20 - 0.35). The top nine risks found to be critical were perceived to be highly likely to occur and to have severe consequences on the performance of highway construction projects in Nigeria. Out of all the risks, project funding change was found to be top on the lists of high criticality (CI = 0. 62; Ranked 1st). One of the major challenges faced in the construction of highway projects in Nigeria is attributable to the funding gap in road infrastructure delivery. Contractors are paid mobilization fees for the start of the work, but as the work progresses, they are no longer paid. The project funding challenge which leads to difficulty in financing can engender project termination and loss of the fund investment (Hwang et al., 2013). Up

till now, the finance of road projects has been through a meagre annual budgetary allocation which has proved insufficient to fund road infrastructural development. The project funding challenge is a lingering issue in most if not all developing countries. This risk was also found to be critical in a study conducted by Zayed et al. (2008), to assess risk and uncertainty inherent in Chinese highway projects and another by Tang et al. (2007), to investigate risk management in the Chinese construction industry. In identifying and assessing critical risk factors in an underground rail project in Thailand this risk was ranked 1st (Ghosh and Jintanapakanont, 2004). It was given high 2nd ranking position a study in Singapore (Hwang et al., 2013).

The second ranked highly critical risk is the construction time delay (CI = 0.60). Construction time delay is a major concern in the delivery of highway construction projects in Nigeria. Insufficient funding can result in delay during construction and lack of effective management in place. This risk was ranked 4th in Indonesia (Wibowo and Mohamed, 2010) and 3rd in Singaporean construction projects (Hwang et al., 2013). Political influence is ranked as the 3rd (CI = 0.59) most critical risk. However, this risk was given 1st ranking in PPP projects in China. This risk is considered highly critical due to the complexity of the Nigerian political system. The level of involvement of the political stakeholders in the delivery of highway projects in Nigeria has made this risk highly critical. This finding is consistent with the findings of Zayed et al. (2008) who assessed risk and uncertainty inherent in Chinese highway projects.

Exchange rate fluctuation and inflation/interest rate fluctuation were ranked 4th and 5th respectively, with risk criticality indices of 0.58 and 0.57 respectively. These risks were considered highly critical as they were both perceived to be highly likely to occur and to have severe consequences. The Nigerian economic situation is currently considered to be in a complete mess. As of the time of initial data collection, the exchange rate to the US Dollar was N140.00 to 1 US Dollar and N250.00 to 1 GBP but as of present it has risen astronomically to over N600.00 to a pound and above N400.00 to 1 US Dollar. This is beyond the control of any project management team; hence it is perceived as being highly critical. It goes hand in hand with the inflation/interest rate. These risks were found to be the most significant in the United Arab Emirates (UAE) construction industry, where it was ranked first (El-Sayegh, 2008). However, it was given low rankings in China (30th) (Fang et al., 2004) and Kuwait (18th), (Kartam and Kartam, 2001). The Nigerian economy is very volatile at the moment. Since Nigeria was unable to attain target exchange rates and expenditure, it was ousted from International

Monetary Fund (IMF) programme in April 2002. The interview finding that is discussed in the next chapter shows that this risk arises from increasing cost of construction materials and labour. Many highway projects in Nigeria last for substantial period of time, and in most cases transfer the cost to the client (the government)

Construction cost overrun is perceived as the 6th (CI = 0.56) top highly critical risk affecting the construction of highway projects in Nigeria. Similarly, this risk was ranked 5th in Indonesia (Wibowo and Mohamed, 2010). The effect of exchange rate fluctuation and inflation/interest rate fluctuation would without doubt result in construction cost overrun, in addition to other factors, like corruption, peculiar to most developing countries. It has been found that this risk is considered critical in most current research, both in developed and developing countries, but it is more pronounced in the developing countries, particularly Nigeria. Government officials demanding bribes /unjust rewards is perceived as the 7th (CI = 0.54) most highly critical risk. No country whether developed or developing is exempted from corruption, but in developing countries it could be worsened due to the lack of a mature legal system and insufficient legal punishments and penalties (Le et al., 2014). Hence, this risk is perceived as being critical. In Chinese PPP Projects this risk occupied the 3rd ranking position. Corruption is a highly significant risk that has very serious consequences on the delivery of highway projects in developing countries; it can result in project cost overrun, time delay and even abandonment of project in developing countries.

The last two on the list are unstable government and the project being cancelled due to a change in the ruling party (CI = 0.54 & 0.52), which were ranked 8th and 9th respectively. They are both political risks and external to the projects. Hence, both critical, just like political influence and have the same implications. Given the long concession duration associated with highway construction projects, any change in government policies or regime will drastically impose additional risks and further costs. Political risks are found to be very low and insignificant in the UAE construction industry but were given high ranking (5th position) in the Singapore construction industries (Hwang et al., 2013). It can be noted that whereas the UAE is a relatively authoritarian society, Singapore and Nigeria are democracies. The high political risks in Nigeria will be seen as discouraging indicators that will not attract foreign investors/contractors to Nigeria.

Table 5- 13: Criticality Index of the identified risk factors affecting the performance of highway construction projects in Nigeria

Risk code	Risk level	Description	PO Mean	Rank	CO Mean	Rank	RC Score	Rank	CI	Comment
HRCR 20	Internal	Project funding challenge	3.98	1	3.92	1	15.6016	1	0.624064	More critical
HRCR 21	Internal	Construction time delay	3.96	2	3.76	6	14.8896	2	0.595584	More critical
HRCR 3	External	Political interference	3.83	3	3.86	2	14.7838	3	0.591352	More critical
HRCR 6	External	Exchange rate fluctuation	3.81	4	3.83	3	14.5923	4	0.583692	More critical
HRCR 7	External	Inflation/interest rate fluctuation	3.79	5	3.75	7	14.2125	5	0.5685	More critical
HRCR 22	Internal	Construction cost overrun	3.66	7	3.8	4	13.908	6	0.55632	More critical
HRCR 5	External	Government officials demand bribe /unjust reward	3.66	6	3.7	8	13.542	7	0.54168	More critical
HRCR 1	External	Unstable government	3.55	9	3.77	5	13.3835	8	0.53534	More critical
HRCR 2	External	Project being cancelled due to change in ruling party	3.56	8	3.64	9	12.9584	9	0.518336	More critical
HRCR 35	Internal	Lack of joint risk mechanism by parties	3.27	10	3.27	11	10.6929	10	0.427716	Less critical
HRCR 17	External	Weak regulatory & monitoring regime	3.22	11	3.24	13	10.4328	11	0.417312	Less critical
HRCR 26	Internal	High maintenance cost	3.2	12	3.26	12	10.432	12	0.41728	Less critical
HRCR 28	Internal	Lack of quality control and monitoring	3	13	3.27	10	9.81	13	0.3924	Less critical
HRCR 34	Internal	Lack of commitment between parties	2.95	15	3.21	15	9.4695	14	0.37878	Less critical
HRCR 23	Internal	Defective design, error and rework	2.9	19	3.23	14	9.367	15	0.37468	Less critical
HRCR 27	Internal	Poor communication within different parties	2.91	18	3.05	18	8.8755	16	0.35502	Less critical
HRCR 14	External	Terrorism attack	2.8	21	3.16	16	8.848	17	0.35392	Less critical
HRCR 25	Internal	Inappropriate procurement methods	2.91	17	2.98	19	8.6718	18	0.346872	Rarely critical
HRCR 11	External	Land acquisition and compensation problems	2.93	16	2.92	20	8.5556	19	0.342224	Rarely critical
HRCR 29	Internal	Subcontractors' incompetence	2.95	14	2.9	22	8.555	20	0.3422	Rarely critical
HRCR 24	Internal	Delay in the availability of design details	2.7	27	3.1	17	8.37	21	0.3348	Rarely critical
HRCR 9	External	Poor relationship with community	2.84	20	2.9	21	8.236	22	0.32944	Rarely critical
HRCR 16	External	Lack of legal regulatory framework	2.76	24	2.86	25	7.8936	23	0.315744	Rarely critical
HRCR 12	External	Inclement weather	2.77	22	2.84	27	7.8668	24	0.314672	Rarely critical
HRCR 18	External	Unavailability of special equipment	2.77	23	2.84	28	7.8668	25	0.314672	Rarely critical
HRCR 4	External	Expropriation /Nationalization	2.71	25	2.85	26	7.7235	26	0.30894	Rarely critical
HRCR 19	External	Failure of major constr. Equip. & Unavailability of spare parts	2.66	28	2.84	29	7.5544	27	0.302176	Rarely critical
HRCR 15	External	Flood	2.59	29	2.88	23	7.4592	28	0.298368	Rarely critical
HRCR 13	External	Adverse ground conditions	2.7	26	2.74	31	7.398	29	0.29592	Rarely critical
HRCR 32	Internal	Shortage of skilled workers	2.48	32	2.88	24	7.1424	30	0.285696	Rarely critical
HRCR 30	Internal	Poor competence of workers	2.58	30	2.61	33	6.7338	31	0.269352	Rarely critical
HRCR 33	Internal	Shortage/unavailability of materials	2.38	35	2.81	30	6.6878	32	0.267512	Rarely critical

HRCR 31	Internal	Shortage of experts in highways	2.5	31	2.66	32	6.65	33	0.266	Rarely critical
HRCR 8	External	Level of public opposition to projects	2.38	34	2.55	34	6.069	34	0.24276	Rarely critical
HRCR 10	External	Landowner unwilling to sell]	2.4	33	2.41	35	5.784	35	0.23136	Rarely critical

Table 5- 14: Classifications of the identified Nigerian highway construction project risks

Identified risk	Risk code	Risk level	Risk description	Criticality index	Description
Highly possible risks	HRCR 20	Internal	Project funding challenge	0.624064	More critical
	HRCR 21	Internal	Construction time delay	0.595584	More critical
	HRCR 3	External	Political interference	0.591352	More critical
	HRCR 6	External	Exchange rate fluctuation	0.583692	More critical
	HRCR 7	External	Inflation/interest rate fluctuation	0.5685	More critical
	HRCR 22	Internal	Construction cost overrun	0.55632	More critical
	HRCR 5	External	Government officials demand bribe /unjust reward	0.54168	More critical
	HRCR 1	External	Unstable government	0.53534	More critical
	HRCR 2	External	Project being cancelled due to change in ruling party	0.518336	More critical
Low risks	HRCR 35	Internal	Lack of joint risk mechanism by parties	0.427716	Less critical
	HRCR 17	External	Weak regulatory & monitoring regime	0.417312	Less critical
	HRCR 26	Internal	High maintenance cost	0.41728	Less critical
	HRCR 28	Internal	Lack of quality control and monitoring	0.3924	Less critical
	HRCR 34	Internal	Lack of commitment between parties	0.37878	Less critical
	HRCR 23	Internal	Defective design, error and rework	0.37468	Less critical
	HRCR 27	Internal	Poor communication within different parties	0.35502	Less critical
	HRCR 14	External	Terrorism attack	0.35392	Less critical
Very low risks	HRCR 25	Internal	Inappropriate procurement methods	0.346872	Rarely critical
	HRCR 11	External	Land acquisition and compensation problems	0.342224	Rarely critical
	HRCR 29	Internal	Subcontractors' incompetence	0.3422	Rarely critical
	HRCR 24	Internal	Delay in the availability of design details	0.3348	Rarely critical
	HRCR 9	External	Poor relationship with community	0.32944	Rarely critical
	HRCR 16	External	Lack of legal regulatory framework	0.315744	Rarely critical
	HRCR 12	External	Inclement weather	0.314672	Rarely critical
	HRCR 18	External	Unavailability of special equipment	0.314672	Rarely critical
	HRCR 4	External	Expropriation /Nationalization	0.30894	Rarely critical
	HRCR 19	External	Failure of major constr. Equip. & Unavailability of spare parts	0.302176	Rarely critical
	HRCR 15	External	Flood	0.298368	Rarely critical
	HRCR 13	External	Adverse ground conditions	0.29592	Rarely critical
	HRCR 32	Internal	Shortage of skilled workers	0.285696	Rarely critical
	HRCR 30	Internal	Poor competence of workers	0.269352	Rarely critical
	HRCR 33	Internal	Shortage/unavailability of materials	0.267512	Rarely critical
	HRCR 31	Internal	Shortage of experts in highways	0.266	Rarely critical
	HRCR 8	External	Level of public opposition to	0.24276	Rarely critical

		projects		
HRCR 10	External	Landowner unwilling to sell	0.23136	Rarely critical

Based on the findings, the risks identified in Nigerian highway construction projects can be classified as shown in Table 5-13. Using the reference scale in Table 5-12, the identified risks can be classified as highly possible risks, low risks and very low possibility risks. Nine risks were found to have high possibility of occurrence, of which 6 of them fall under external risk factor type while the remaining three fall under the internal risk factor type. These nine risk factors are regarded as the top nine high risk factors that will have highly critical consequences on the performance of highway infrastructure construction projects in Nigeria, based on their criticality rating. They are represented in Table 5-14 and will be given further attention in the framework development chapter.

8 risk factors were found to be perceived to have low possibility of occurrence and with less critical consequences should they occur. Six of these fall within the internal risk factor type while the remaining two belong to the external type. The third category comprises risks that were perceived to have very low possibility of occurrence and were considered to be rarely critical should they occur. They are 18 of these, of which 11 belong to the external risk factor type while the remaining 7 are found to be linked to the internal risk factor type.

Table 5-15: Top nine most important risks in the Nigerian highway construction projects

Risk code	Risk descriptions	Criticality index	Ranking
HRCR 20	Project funding challenge	0.624064	1
HRCR 21	Construction time delay	0.595584	2
HRCR 3	Political interference	0.591352	3
HRCR 6	Exchange rate fluctuation	0.583692	4
HRCR 7	Inflation/interest rate fluctuation	0.5685	5
HRCR 22	Construction cost overrun	0.55632	6
HRCR 5	Government officials demand bribe /unjust reward	0.54168	7
HRCR 1	Unstable government	0.53534	8
HRCR 2	Project being cancelled due to change in ruling party	0.518336	9

5.6 Risk management processes and techniques currently used in Nigerian highway construction projects and their effectiveness (Section 3)

This section of the questionnaire investigated risk management processes and techniques currently used in the Nigerian highway infrastructure construction projects and their effectiveness. The question was designed to satisfy research objective 3

5.6.1 Risk identification techniques

Respondents were requested to indicate the extent of the usage of six risk identification techniques in their organisation to identify potential risks associated with highway infrastructure construction projects in Nigeria; this was indicated on a Likert scale of 1 – 4 where 1 = Never used; 2 = seldom used; 3 = often used; and 4 = always used. An overall mean ranking was computed for each of the group (government, international contractors, local contractors, consultants and joint venture) using SPSS version 22, as shown in table 5-16. The results show that consulting experts (mean = 3.15; rank = 1st) is the most often used technique to identify risk in Nigerian highway projects, followed by brainstorming (mean = 3.05; rank = 2nd); checklist (mean = 2.98, rank = 3rd); historical data (mean = 2.95; rank = 4th); intuition/judgement (mean = 2.80; rank = 5th) and interview (mean = 2.4; rank = 6th). There was no significant difference in opinion among the various groups, as revealed by the Kruskal-Wallis test, $p > 0.05$, as shown in Table 5-16. This suggests that the extent to which all groups used risk identification techniques was similar. Previous studies found that consulting experts was ranked 1st in the Pakistan construction industry (Choudhry and Iqbal, 2013); brainstorming was ranked 1st followed by consulting experts in the Chinese construction industry (Tang et al., 2007); questionnaires together with checklist and scenario building were the most frequently used in New South Wales, Australia (Bajaj et al., 1997); brainstorming followed by case based approach and checklist in in the Australian construction industry (Lyons and Skitmore, 2004). Historic data was ranked first (54%) followed by case based approach (48.7%) and intuition/judgement/experience (43.6%) in the Singapore construction industry (Hlaing et al., 2008); There are similarities between Nigerian and Pakistan in the risk identification techniques used to identify risk in projects. It is slightly similar to that of Chinese construction industry, although consulting experts was not ranked first in China; brainstorming occupied the second position in both countries. It is noted that in a cultural homogeneous country such as Australia there was difference in the usage of risk identification techniques as revealed by Bajaj et al.

(1997) and Lyons and Skitmore (2004). This could be a reflection of the fact that there is no single best method of risk identification techniques (Hillson, 2002; Choudhry et al., 2014). Additionally, the application of those tools depends on the nature of the project, the organisation's policy, the project management strategy, the risk attitudes of project team members and the availability of resources (Dey and Ogunlana 2004).

5.6.1.1 Effectiveness of risk identification techniques

Respondents were further requested to rate the effectiveness of the use of the above 6 risk identification techniques in their organisation to identify the potential risks associated with highway infrastructure construction projects in Nigeria, using the same Likert scale as in section 5.3.1 where 1 = not at all effective; 2 = slightly effective; 3 = effective; and 4 very effective. An overall mean ranking was computed for each of the groups (government, international contractors, local contractors, consultants and joint ventures) using SPSS version 22, as shown in Table 6-17. The result shows that consulting expert (mean = 3.43; rank = 1) was found more effective followed by brainstorming (mean = 3.18; rank = 2nd). The Kruskal-Wallis test revealed that there was no significant difference in opinion regarding the effectiveness of risk identification techniques used in Nigerian highway projects. It appears that there is no single agreed best method of risk identification and that a combination of techniques should be employed and with collective responsibility rather than on an individual basis as the experience of an individual can be limited (Choudhry et al., 2014; Caltrans, 2012; PM1, 2008).

5.6.2 Risk analysis technique

On the risk analysis techniques, respondents were requested to indicate the extent of the usage of the four risk analysis techniques in their organisation to analyse the identified risks associated with highway infrastructure construction projects in Nigeria, using the same Likert scale as in section 5.3.1. An overall mean ranking was computed for each of the groups (government, international contractors, local contractors, consultants and joint ventures) using SPSS version 22, as shown in Table 5-18. The results show that consulting experts (mean = 3.26, rank = 1st) was more often used, followed by qualitative analysis (mean = 3.23; rank = 2nd); quantitative analysis (mean = 3; rank = 3rd) and use of computers and other modelling techniques (mean = 2.86; rank = 4th). There was no significant difference in opinion among the various groups as revealed by

the Kruskal-Wallis test, $p > 0.05$, as shown in Table 5-18. Previous studies found that in the UK, intuition/judgement/experience was most frequently used followed by sensitivity analysis (Akintoye and Macleod, 1997); however, in China, joint evaluation by key participants was most frequently used followed by qualitative analysis (Tang et al, 2007) while in Pakistan none of the techniques had a mean ranking of up to 2.50 (Choudhry et al., 2014). The highest mean ranking was 2.20 for qualitative risk analysis, implying that analysis is seldom applied for already identified risks.

Table 5-16: Risk identification techniques in highway construction projects in Nigeria by different groups of participants

Code	Description	Government		Int'l Contractor		Local Contractor		Consultant		Joint Venture		**Overall**		Kruskal Wallis Test	
		Mean	R	Mean	R	Mean	R	Mean	R	Mean	R	**Mean**	**R**	x^2	Sig. p
HRIT 1	Historical data	2.79	4	3	3	3.04	3	2.97	4	2.5	4	2.95	4	2.294	0.682
HRIT 2	Checklists	3.04	2	2.91	4	2.83	5	3.16	2	3	1	2.98	3	3.313	0.507
HRIT 3	Brainstorming	3.07	1	3.05	2	3.08	2	3.03	3	3	2	3.05	2	0.26	0.992
HRIT 4	Intuition/judgement	2.68	5	2.81	5	2.96	4	2.81	5	2.5	5	2.8	5	1.86	0.761
HRIT 5	Interview	2.46	6	2.3	6	2.21	6	2.65	6	2	6	2.4	6	4.358	0.36
HRIT 6	Consulting experts	3	3	3.09	1	3.17	1	3.35	1	3	3	3.15	1	2.787	0.594

Table 5- 17: Effectiveness of risk identification techniques in highway construction projects in Nigeria by different groups of participants

Code	Description	Government		Int'l Contractor		Local Contractor		Consultant		Joint Venture		**Overall**		Kruskal Wallis Test	
		Mean	R	Mean	R	Mean	R	Mean	R	Mean	R	**Mean**	**R**	x^2	Sig. p
EHRIT 1	Historical data	3.04	3	2.98	4	2.96	4	3.06	3	3	1	3.01	4	1.175	0.882
EHRIT 2	Checklists	3.04	4	3.02	3	3.04	3	3	4	3	2	3.02	3	0.254	0.993
EHRIT 3	Brainstorming	3.11	2	3.16	2	3.13	2	3.32	2	3	3	3.18	2	1.171	0.883
EHRIT 4	Intuition/judgement	2.54	6	2.65	5	2.96	5	2.48	6	2.5	5	2.64	5	4.204	0.379
EHRIT 5	Interview	2.61	5	2.49	6	2.29	6	2.9	5	2.5	6	2.58	6	9.145	0.058
EHRIT 6	Consulting experts	3.32	1	3.3	1	3.5	1	3.68	1	3	4	3.43	1	5.715	0.221

The findings in the current research suggest a combination of techniques was adopted in analysing the identified risk and this is consistent with the literature findings.

5.6.2.1 Effectiveness of risk identification techniques

On the risk analysis techniques, respondents were further requested to indicate the effectiveness of the use of the four risk analysis techniques in their organisation to analyse the identified risks associated with highway infrastructure construction projects in Nigeria, using the same Likert scale as in section 5.3.1. An overall mean ranking was computed for each of the group (government, international contractors, local contractors, consultants and joint ventures) using SPSS version 22 as shown in Table 5-19. Consulting experts (mean = 3.29; rank = 1st) was found to be more effective, followed by qualitative analysis (mean = 3.08; rank = 2nd); quantitative analysis (mean = 3.01; rank = 3rd) and computers and other modelling techniques (mean = 2.97; rank = 4th)

5.6.3 Risk response techniques

On the risk response techniques, respondents were requested to indicate the extent of the use of the six risk response techniques in their organisation to handle risks associated with highway infrastructure construction projects in Nigeria, using the same Likert scale as in section 5.3.1. An overall mean ranking was computed for each of the groups (government, international contractors, local contractors, consultants and joint ventures) using SPSS version 22, as shown in Table 5-20. The results show that reducing the possibility of occurrence (mean= 3.03; rank = 1st) was more often used to respond to risk in Nigerian highway projects, followed by reducing the consequence of occurrence (mean = 3.02, rank = 2nd); avoiding the risks (mean = 2.77, rank = 3rd); transferring the risk (mean = 2.45; rank = 3rd); sharing the risks (mean = 2.43; rank = 5th) and retaining the risk (2.11, rank = 4th). The Kruskal-Wallis test revealed that there was no significant difference in opinion among the different groups regarding the risk response techniques, except in risk transfer, where $p = 0.04 < 0.05$ which was given relatively high ranking by participants from joint ventures and international contractors. Previous studies found that reducing the consequence and reducing the possibility were most often used in China (Tang et al, 2007) which is consistent with the above finding; however, in contrast, risk avoidance and risk transfer are the most often used in Pakistan (Choudhry et al, 2014).

Table 5- 18: Evaluation of risk analysis techniques in highway construction projects in Nigeria by different groups of participants

Code	Description	Government		Int'l Contractor		Local Contractor		Consultant		Joint Venture		**Overall**		Kruskal Wallis Test	
		Mean	R	Mean	R	Mean	R	Mean	R	Mean	R	**Mean**	**R**	x^2	Sig. p
HRAT 1	Qualitative risk analysis	3.14	2	3.37	1	3.04	3	3.29	2	2.5	1	3.23	2	6.429	0.169
HRAT 2	Quantitative risk analysis	2.93	3	3.07	3	3.17	2	2.87	4	2.5	2	3	3	3.589	0.464
HRAT 3	Consulting experts	3.18	1	3.16	2	3.29	1	3.48	1	2.5	3	3.26	1	5.878	0.208
HRAT 4	computers and other modelling techniques	2.75	4	2.79	4	2.96	4	3.03	3	2	4	2.86	4	3.716	0.446

Table 5- 19 Evaluation of the effectiveness of risk analysis techniques in highway construction projects in Nigeria by different groups of participants

Code	Description	Government		Int'l Contractor		Local Contractor		Consultant		Joint Venture		**Overall**		Kruskal Wallis Test	
		Mean	R	Mean	R	Mean	R	Mean	R	Mean	R	**Mean**	**R**	x^2	Sig. p
EHRA 1	Qualitative risk analysis	2.93	4	3.02	2	2.96	3	3.35	2	3.5	1	3.08	2	6.008	0.199
EHRA 2	Quantitative risk analysis	2.96	2	2.98	3	3.17	1	2.97	4	3	3	3.01	3	1.774	0.777
EHRA 3	Consulting experts	3.36	1	3.19	1	3.08	2	3.55	1	3	4	3.29	1	8.492	0.075
EHRA 4	computers and other modelling techniques	2.96	3	2.95	4	2.88	4	3.03	3	3.5	2	2.97	4	1.424	0.84

Risk reduction was found to be most often used in Australia and Singapore construction industries (Lyons and Skitmore, 2004; Hlaing et al., 2008). The above findings further illustrate that there is no best method of risk response and a combination of techniques would be appropriate.

5.6.3.1 Effectiveness of risk response techniques

On the risk response technique, respondents were requested to indicate the effectiveness of the use of the six risk response techniques to handle risks associated with highway infrastructure construction projects in Nigeria, using the same Likert scale as in section 5.3.1. An overall mean ranking was computed for each of the groups (government, international contractors, local contractors, consultants and joint ventures), using SPSS version 22, as shown in Table 5-21. Reducing the consequence of occurrence (mean = 2.96) was found to be considered the most effective risk response technique, followed by: reducing the possibility of occurrence (mean = 2.95); avoiding the risk (mean = 2.77); sharing the risk (mean = 2.48); transferring the risk (mean = 2.35) and retaining the risk (mean = 2.06). A computed Kruskal-Wallis test showed no significant difference in opinion among the different groups regarding the effectiveness of risk response techniques, except for reducing the possibility of occurrence. This was given relatively low ranking by the contractors compared with the rest of the groups.

Table 5-20: Evaluation of risk response techniques in highway construction projects in Nigeria by different groups of participants

Code	Description	Government		Int'l Contractor		Local Contractor		Consultant		Joint Venture		**Overall**		Kruskal Wallis Test	
		Mean	R	Mean	R	Mean	R	Mean	R	Mean	R	**Mean**	**R**	x^2	Sig. p
HRRT 1	Reduce the possibility of occurrence	3	1	3.09	2	2.75	2	3.16	1	3.5	1	3.03	1	4.234	0.375
HRRT 2	Reduce the consequences of occurrence	2.96	2	3.19	1	2.96	1	2.9	2	3	2	3.02	2	3.168	0.53
HRRT 3	Avoiding the risks	2.82	3	2.74	4	2.63	3	2.87	3	3	3	2.77	3	1.19	0.88
HRRT 4	Transferring the risks	2.29	5	2.77	3	2.42	4	2.13	6	3	4	2.45	4	10.055	0.04**
HRRT 5	Retaining the risks	2.25	6	2.09	6	1.92	6	2.16	5	2	6	2.11	6	1.546	0.818
HRRT 6	Sharing the risks	2.54	4	2.49	5	2.29	5	2.32	4	3	5	2.43	5	3.338	0.503

** Statistically significant differences in opinion on the rating of risk response techniques

Table 5- 21: Evaluation of the effectiveness of risk response techniques in highway construction projects in Nigeria by different groups of participants

Code	Description	Government		Int'l Contractor		Local Contractor		Consultant		Joint Venture		**Overall**		Kruskal Wallis Test	
		Mean	R	Mean	R	Mean	R	Mean	R	Mean	R	**Mean**	**R**	x^2	Sig. p
EHRRT 1	Reduce the possibility of occurrence	2.89	2	2.86	1	2.63	2	3.35	1	3	2	2.95	2	11.413	0.022**
EHRRT 2	Reduce the consequences of occurrence	3.04	1	2.84	2	2.96	1	3.06	2	3	3	2.96	1	1.68	0.794
EHRRT 3	Avoiding the risks	2.75	3	2.58	3	2.63	3	3.1	3	3.5	1	2.77	3	7.801	0.099
EHRRT 4	Transferring the risks	2.36	5	2.49	4	2.29	4	2.16	5	3	4	2.35	5	3.6	0.463
EHRRT 5	Retaining the risks	2.04	6	2.02	6	2.17	6	2	6	3	5	2.06	6	3.377	0.497
EHRRT 6	Sharing the risks	2.68	4	2.44	5	2.21	5	2.55	4	3	6	2.48	4	5.246	0.263

** Statistically significant differences in opinion on the rating of effectiveness of risk response techniques

5.7 Chapter summary

This chapter has presented the first part of the quantitative data analysis aspect of the research findings. It presented the findings regarding the risks associated with highway construction projects in Nigerian and classified them into various groups and levels. The top nine risks perceived to affect the performance of highway infrastructure construction projects in Nigerian were then identified. The risk management processes and techniques currently used in highway construction projects in Nigeria and their effectiveness were also identified from the analysis of the questionnaire results.

Chapter 6: Factor analysis of Nigerian highway construction project risks

6.1 Introduction

This chapter is a continuation of Chapter 5 (quantitative data analysis). It presents a factor analysis of the 35 risk factors identified from the literature and classifies them into 10 factor groupings.

6.2 Factors analysis of the Nigerian highway construction infrastructure project risks

Factors analysis was applied to the 35 risk factors to assess whether these factors can be grouped under different factors and to classify them into a manageable number of factors. According to Tran and Molenaar (2013), factor analysis has the primary objective of describing and capturing the interrelationship among many variables in terms of a few underlying factors that can be used to represent the whole sample. The Statistical Package for Social Science (SPSS) version 22 was used in computing the factor analysis, employing the procedure demonstrated in Figure 6-1. Specifically, the factor analysis investigates the relationship among the 35 highway risk factors that affect the performance of highway construction projects in Nigeria.

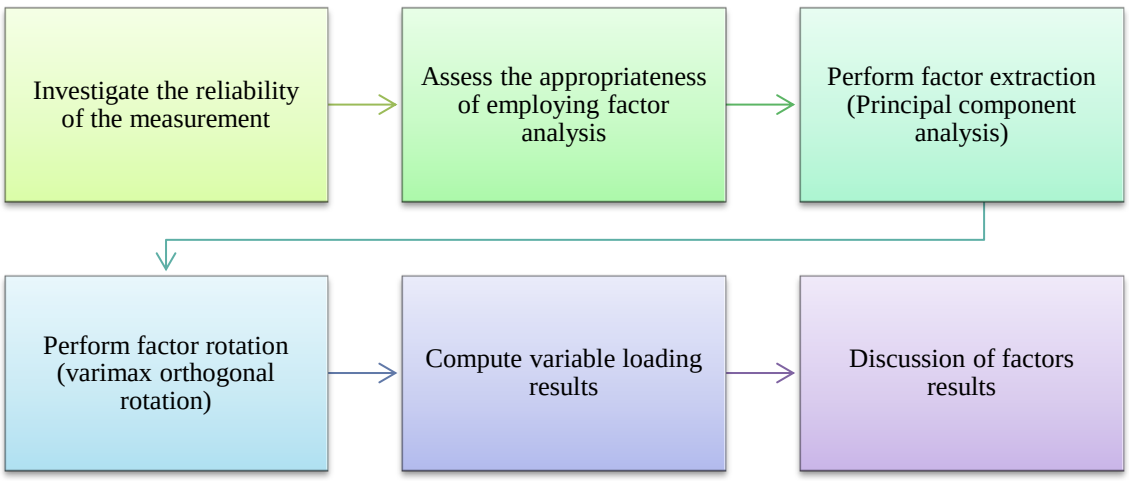

Figure 6- 1: Factor analysis procedures

6.2.1 Investigation of the reliability of measurement for factor analysis

Before proceeding with factor analysis, the reliability of the scales used in the collected data and the appropriateness of employing factor analysis must first be assessed. The Cronbach alpha coefficient (∝) has been widely used in construction project management research to assess the reliability of the scale used in the collected data. Hence, it was employed here to investigate the reliability of the collected data. Subsequently, the appropriateness of factor analysis was assessed by employing the Kaiser-Mayer-Olkin (KMO) test and Bartlett's test of sphericity.

The (∝) can be computed using equation 5.5, adapted from Alroomi et al., (2011)

$$\alpha = \frac{N^2.\bar{\mathrm{Cov}}}{\sum S^2 + \sum \mathrm{Cov}} \qquad \text{……Equation 6.1}$$

Where N denotes number of risk factors; $\overline{cov}$ = average covariance between the risks; Cov = covariance of the risk that measures the strength of relation between two risks; and S^2 = variance of the risk. The Cronbach alpha coefficient (∝) on the five-point Likert scale used to investigate risk factors associated with Nigerian highway infrastructure construction projects is .905 (Table 6-1), far above the recommended lower limit of 0.5 (Wang and Yuan, 2011). This shows that the scale is very reliable. The results for the coefficient (∝) range from 0 – 1: the closer the (∝) value is to 1, the higher the reliability of the scale.

Table 6- 1: Reliability statistic

Cronbach's Alpha	905	N of Items	35

6.2.2 Assessing the appropriateness of employing factor analysis

The KMO measure test is used to assess if the collected sample size and the number of variables is adequate to allow for factor analysis to progress. KMO denotes the ratio of the squared correlation between risks to the squared partial correlation between variables, as shown in equation 5.6, adapted from Alroomi et al. (2011).

$$\text{KMO} = \frac{(Correlation\ between\ variable)^2}{(Partial\ correlation\ between\ variables)^2} \qquad \text{……Equation 6.2}$$

where the correlation between variables determines the degree of relationship between all variables (the 35 risk factors) and partial correlation between variables determines the degree of relationship among two variables, whilst eliminating the effect of other variables to assess if the collected data are adequate to enable the use of factor analysis. Bartlett's test of sphericity decides whether the correlation matrix is an identity matrix. The presence of an identity matrix would imply factor analysis will not be useful. The result of the KMO is 0.786 (Table 6-2) which is greater than the threshold of 0.5 recommended in literature (Ghosh and Jintanapakanont, 2004; Alroomi et al., 2011; Wang and Yuan, 2011). Hence, the KMO result implies that the sample size and the number of variables satisfied the fundamental requirement for factor analysis. Bartlett's test of sphericity result was found to be 2162.375 (Table 6-2) with an associated significance test statistic of 0.000, implying that the correlation matrix is not an identity matrix, therefore it is considered appropriate to progress with the factor analysis.

Table 6- 2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.786
Bartlett's Test of Sphericity	Approx. Chi-Square	2162.375
	df	595
	Sig.	0.000

6.2.3 **Factor extraction (Principal component analysis**)

Having shown that the collected data satisfied the conditions to progress with factor analysis, the 35 risk factors were subjected to factor loading using principal component analysis and varimax rotation. The principal component analysis uses eigenvalues to reduce number of variables into a smaller number of factors. Many criteria are used to decide which factors are to be retained. The most widely used criterion is Kaiser's criterion, in which case factors with eigenvalues greater than 1.00 are retained and those below 1.00 are disregarded (Ghosh and Jintanapakanont, 2004; Alroomi et al., 2011; Tang et al., 2014). It was also recommended that the percentage of variance for the factors extracted should not be less than 60% of total variance (Alroomi et al., 2011; Tran and Molenaar; 2013; Tang et al., 2014). The results of the principal component analysis to determine the factors to be retained as shown in Table 6-3. In accordance with Kaiser's criteria, 10 Factors have eigenvalues greater than 1.00, which are thus the recommended factors to be retained. These 10 risk factors explain 69.50% of the total

variance in the data, which is above the recommended threshold of 60%. The scree plot test is another commonly used criterion for the selection of the factors to be retained (Tang et al., 2014). The plot produced by the SPSS is assessed to locate the point at which the shape of the curve changes direction, as shown in Figure 6-2. It can be seen that the contributions are relatively low after the 10th component.

Table 6- 3: Principal component analysis results

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.861	25.317	25.317	8.861	25.317	25.317	3.726	10.646	10.646
2	2.759	7.883	33.200	2.759	7.883	33.200	3.424	9.782	20.429
3	2.201	6.290	39.490	2.201	6.290	39.490	2.677	7.649	28.077
4	2.060	5.886	45.376	2.060	5.886	45.376	2.358	6.736	34.813
5	1.830	5.227	50.603	1.830	5.227	50.603	2.330	6.656	41.469
6	1.599	4.568	55.171	1.599	4.568	55.171	2.202	6.292	47.762
7	1.519	4.341	59.512	1.519	4.341	59.512	2.197	6.278	54.040
8	1.312	3.750	63.261	1.312	3.750	63.261	2.036	5.816	59.856
9	1.167	3.335	66.596	1.167	3.335	66.596	1.978	5.651	65.507
10	1.016	2.903	69.499	1.016	2.903	69.499	1.397	3.993	69.499
11	.988	2.821	72.321						
12	.918	2.622	74.943						
13	.746	2.130	77.074						
14	.714	2.040	79.114						
15	.665	1.900	81.014						
16	.624	1.782	82.796						
17	.584	1.668	84.464						
18	.551	1.576	86.040						
19	.519	1.482	87.522						
20	.482	1.378	88.899						
21	.442	1.262	90.161						
22	.398	1.138	91.299						
23	.381	1.089	92.388						
24	.349	.997	93.385						
25	.303	.866	94.252						
26	.295	.844	95.095						
27	.272	.777	95.872						
28	.237	.678	96.550						
29	.229	.655	97.205						
30	.207	.593	97.797						

31	.186	.531	98.329
32	.178	.508	98.836
33	.156	.445	99.281
34	.147	.420	99.701
35	.105	.299	100.000

Note: Extraction Method: Principal Component Analysis.

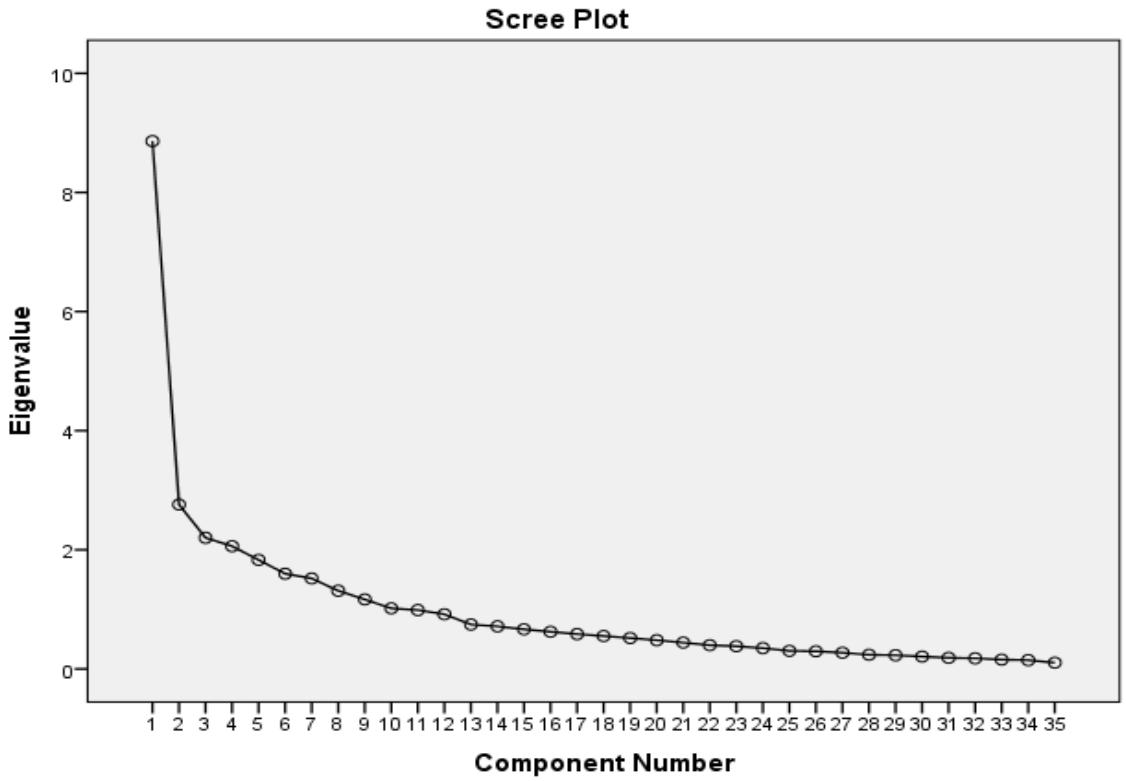

Figure 6-2: Scree plot showing the extracted factors of the 35 risk factors

Table 6-4 shows the results of the 35 risk factor loadings scattered between the components with most risks loaded highly into the 1st factors, then the 2nd and3rd components, as can be seen. This made factor interpretation complicated due to the indistinct pattern of the factor matrix. As a result, factor rotation became necessary for effective interpretation of the factors. Two main types of factor rotation exist (varimax orthogonal and oblique rotations) but varimax orthogonal rotation was preferred to lead the most interpretable factors (Ghosh and Jintanapakanont, 2004; Alroomi et al., 2011). Table 6-5 shows the result after varimax orthogonal rotation was performed. The results indicate only the highest loadings on each factor; adopting the approach used by Alroomi et al. (2011), loadings of less than $\pm$ 0.4 were removed, since they are considered insignificant for factor interpretation. The factor loading values indicate the

amount of contribution of individual risk factors for each underlying grouping. Table 6-6 summarises the 10 factors and their components. It is worth noting that, although factor analysis groups the variables (factor components) that have large loading for the same factors, it does not attach labels to the factors (Tran and Molenaar, 2013). Following the recommendation of Tran and Molenaar (2013), the 10 risk factors were defined based on the analysis of the loading distributions from 35 risks and the way they were grouped together from the factor analysis.

Table 6- 4: Factor analysis results: un-rotated factors

	Component									
	1	2	3	4	5	6	7	8	9	10
Availability of design details	.673								.261	
Defective design, error and rework	.658									
Inappropriate procurement methods	.642				-.308			-.409		
Shortage of skilled workers	.639			-.499						
Failure of major constr. equipment & Unavailability of spare parts	.636							-.442		
Poor communication within different parties	.631				-.332					
Lack of commitment between parties	.625			-.333			.302			
Poor competence of workers	.619			-.323	.308					
Lack of quality control and monitoring	.614									
Subcontractors' incompetence	.611									
Unavailability of special equipment	.610									
Shortage of experts in highways	.608			-.498						
Shortage/unavailability of materials	.588			-.381						.381
Lack of legal regulatory framework	.564	-.336								
High maintenance cost	.535									-.390
Land acquisition and compensation problems	.529									
Inclement weather	.520	-.397		.322						
Flood	.511	-.479								
Weak regulatory & monitoring regime	.497	.300					-.382			
Landowner unwilling to sell	.473	-.376	.327							
Adverse ground conditions	.470	-.436	-.397	.303						
Lack of joint risk mechanism by parties	.448	.367				-.405	.322			
Poor relationship with community	.446							.344		
Construction cost overrun	.437		-.436							
Political interference	.280	.526	.433							
Project being cancelled due to change in ruling party	.345	.450	.512							

Level of public opposition to projects	.368		.434				.430		
Project funding challenge		.335		.369					
Exchange rate fluctuation		.384	-.427		.500				
Inflation/interest rate fluctuation			-.353		.370				.331
Construction time delay	.348					-.519			
Government officials demand bribe /unjust reward	.416	.308					-.507		
Unstable government			.390		.354	.400	.456		
Expropriation /Nationalization					.411			.631	
Terrorist attack	.430				-.399	.316		-.445	

Extraction Method: Principal Component Analysis.

.

Table 6- 5: Factor analysis results using varimax orthogonal rotation

Risk factor description	Principal Component									
	1	2	3	4	5	6	7	8	9	10
Shortage of skilled workers	.854									
Shortage of experts in highways	.815									
Poor competence of workers	.758									
Shortage/unavailability of materials	.617									
Construction cost overrun		.742								
Availability of design details		.689								
Defective design, error and rework		.633								
Inappropriate procurement methods		.610								
Adverse ground conditions		.545								
Inclement weather		.517								
Level of public opposition to projects			.755							
Poor relationship with community			.697							
Flood			.644							
Lack of legal regulatory framework			.402							
Government officials demand bribe /unjust reward				.679						
Weak regulatory & monitoring regime				.607						
Poor communication within different parties				.411						
Landowner unwilling to sell					.701					
Land acquisition and compensation problems					.650					
Failure of major constr. equipment & Unavailability of spare parts					.603					
Unavailability of special equipment					.501					
Lack of joint risk mechanism by parties						.750				
Construction time delay						.640				
Lack of commitment between						.589				

parties				
Unstable government	.832			
Project being cancelled due to change in ruling party	.739			
Political interference	.710			
Exchange rate fluctuation		.822		
Inflation/interest rate fluctuation		.791		
Project funding challenge		.448		
High maintenance cost			.654	
Lack of quality control and monitoring			.628	
Subcontractors' incompetence			.572	
Expropriation /Nationalization				-.792
Terrorist attack				.633

Extraction Method: Principal Component Analysis

Rotation Method: Varimax with Kaiser Normalization

Table 6-6: Ten factor groups of highway project risks in Nigeria

Factors of risk	% variance explained	Risk included in each factor
Factor 1: Resource risks	25.317	Shortage of skilled workers Shortage of experts in highways Poor competence of workers Shortage/unavailability of materials
Factor 2: Construction	7.883	Construction cost overrun Availability of design details Defective design, error and rework Inappropriate procurement methods Adverse ground conditions Inclement weather
Factor 3: Social risks	6.290	Level of public opposition to projects Poor relationship with community Flood Lack of legal regulatory framework
Factor 4: Corruption	5.886	Government officials demand bribe /unjust reward Weak regulatory & monitoring regime Poor communication within different parties
Factor 5: Land &Equip	5.227	Landowner unwilling to sell Land acquisition and compensation problems Failure of major constr. equipment & Unavailability of spare parts Unavailability of special equipment
Factor 6: Third party	4.568	Lack of joint risk mechanism by parties Construction time delay Lack of commitment between parties
Factor 7: Political	4.341	Unstable government Project being cancelled due to change in ruling party Political interference
Factor 8: Econ/Financial	3.750	Exchange rate fluctuation Inflation/interest rate fluctuation Project funding challenge
Factor 9: Operational	3.335	High maintenance cost Lack of quality control and monitoring Subcontractors' incompetence
Factor 10: Force Majeure	2.903	Expropriation /Nationalization Terrorist attack

6.3 Discussion of factor analysis results

This section explains the 10 factors in detail and discusses the reasons why they are particularly relevant to the delivery of highway infrastructure construction projects in Nigeria. Factor analysis contributes to the development of the risk management framework by specifying the grouping of the high priority risks. The key risk that falls into the same factor grouping can be given the same management attention. (See appendix 10). The primary objective of factor analysis lies in describing and capturing the interrelationship among many variables in terms of a few underlying factors that can be used to represent the whole sample. Within each factor grouping, the higher, the factor loading, the greater the contributing impact of those risks.

6.3.1 Factor 1: Resource risks

Resource risk accounted for 25.32% of the total variance of risk factor in the delivery of highway infrastructure construction projects in Nigeria (Table 6-6). Resource risk comprises four components that have factor loadings between (0.617 and 0.854): shortage of skilled workers, shortage of experts in highways, poor competence of workers, and shortage/unavailability of materials. As shown in Table 6-5, shortage of skilled workers contributed most to this risk, with shortage/unviability of material being the smallest contributor. These components of risk factors can have significant consequences on the performance of highway construction projects, particularly in the areas of time and quality performance criteria. Tran and Molenaar (2013) noted that staff experience and availability directly affect the delivery of highway projects and so does the availability of construction materials.

6.3.2 Factor 2: Construction risk

Construction risk accounted for 7.88% of total variance of risk factor in the delivery of highway infrastructure construction projects in Nigeria (Table 6-6). It is associated with six components with factor loadings between (0.517 and 0.742): construction cost overrun, availability of design details, defective design, error and rework, inappropriate procurement methods, adverse ground conditions and inclement weather. All of these risks are important components of construction risk with construction cost overrun topping the list and inclement weather being the least, as revealed by the factor loading. Failure to execute project in due time is suggested to be accounted for by construction

cost overrun. Unavailability of design details, defective design, error and rework, inappropriate procurement methods, adverse ground conditions and inclement weather also play significant role in the delivery of highway construction projects. Any of these can adversely affect all the performance criteria of a highway project.

6.3.3 Factor 3: Social risks

The social risk factor accounted for 6.29% of the total variance of risk factor in the delivery of highway infrastructure construction projects in Nigeria (Table 6-6). It comprises four components: level of public opposition to projects, poor relationship with the community, flood, and lack of legal regulatory framework with factor loadings between 0.402 and 0.755 (table 6-5). Level of public opposition to projects carries the highest loading and lack of legal regulatory framework the least loading. These risks have serious negative impact on the performance of highway construction projects in Nigeria; particularly in the Niger Delta Region of Nigeria (The Nigerian oil zone).

6.3.4 Factor 4: Corruption risk

Corruption risk factors accounted for 5.89% of the total variance of risk factors in the delivery of highway infrastructure construction projects in Nigeria. This risk factor consists of 3 components: government officials demand bribe /unjust reward, weak regulatory & monitoring regime and poor communication within different parties, with factor loadings between 0.411 and 0.679. Government officials demand bribe /unjust reward takes the lead in contributing to this factor, with poor communication within different parties being the least. The consequence of corruption on the delivery of highway construction project cannot be over emphasized, as previously explained in section 5.2.3

6.3.5 Factor 5: Land & Equipment risk

Land and Equipment risks accounted for 5.23% of the total variance of risk factors in the delivery of highway infrastructure construction projects in Nigeria. This risk factor consists of 4 components: landowner unwilling to sell; land acquisition and compensation problems, failure of major construction equipment & unavailability of spare parts and unavailability of special equipment with factor loadings between (0.501 and 0.701). Land owner unwilling to sell and compensation problems made the highest contribution to this risk factor, with lack of special equipment being the lowest. Land owner unwilling to sell and compensation were serious risks associated with the construction of highway projects in Nigeria. People are not willing to sell their land, as they believe it to be a family inheritance. The government forcefully encroaches into

their property and does not wish to compensate them appropriately. This inevitably results in community violence which greatly impacts construction projects.

6.3.6 Factor 6: Third party risk

Third party risks accounted for 4.57% of the total variance of risk factors in the delivery of highway infrastructure construction projects in Nigeria. This risk is made up of 3 components: Lack of joint risk mechanism by parties, construction time delay and lack of commitment between parties, with the factor loadings between (0.589 and 0.750). Lack of a joint risk management mechanism by the parties contributed most highly to this risk factor, with lack of commitment between the parties making the lowest contribution. This indicates the absence of joint risk management practices among the highway professionals in Nigeria. For effective risk management, all the key project stakeholders should be actively involved.

6.3.7 Factor 7: Political risk

The political risk factor for accounted for 4.34% of the total variance of risk factors in the delivery of highway infrastructure construction projects in Nigeria. This risk factor consists of 3 components: unstable government, project being cancelled due to change in ruling party and strong political interference, with factor loadings between (0.710 and 0.832). These are all high loading factor values, with unstable government leading in its high contribution, followed by project being cancelled due to change in ruling party and political interference. This demonstrates the high level of significance of these risks to the performance of highway construction projects in Nigeria. As pointed out earlier, Nigeria, being rich in oil, is politically unstable with inadequate infrastructure coupled with government corruption and poor macroeconomic management.

6.3.8 Factor 8: Economic/Financial

Economic and financial risks accounted for 3.75% of the total variance of the risk factors in the delivery of highway infrastructure construction projects in Nigeria. It comprises: exchange rate fluctuation, inflation/interest rate fluctuation and project funding challenge, with factor loadings between (0.448 and 0.822). Exchange rate fluctuation provided the highest contribution to this risk factor, followed by inflation/interest rate fluctuation with a lower contribution from project funding

challenge. The consequences of this factor have been discussed in the previous chapter (section 5.2.3).

6.3.9 Factor 9: Operational risk

Operational risks accounted for 3.34% of the total variance of the risk factors in the delivery of highway infrastructure construction projects in Nigeria. This factor comprises of 3 components: high maintenance cost, lack of quality control and monitoring and subcontractors' incompetence, with factor loadings between (0.572 and 0.654). High maintenance cost made the highest contribution to these risk factors followed by lack of quality control and monitoring and subcontractors' incompetence.

6.3.10 Factor 10: Force Majeure

Force majeure risk accounted for 2.90% of the total variance of the risk factors in the delivery of highway infrastructure construction projects in Nigeria. It consists of 2 risk factor components: expropriation /nationalization and terrorism attacks with factor loadings of 0.792 and 0.633 respectively. These factors can impact negatively on the performance of highway construction projects.

6.4 Chapter summary

This chapter presented the further results of factor analysis of the risk factors associated with highway construction projects in Nigeria, under which 10 groupings were identified from the factor analysis result. These include: resource risk, construction risk, social risk, corruption risk, land and equipment risk, third party risk, political risk, political/financial risk and operational risk.

Chapter 7: Qualitative Data Analysis - Case Study Interviews

7.1 Introduction

This chapter presents the qualitative data analysis, findings of four case studies of highway infrastructure construction projects in Nigeria. The main aim of the case studies was to expand the findings of questionnaire survey. The interviews covered three main broad aspects: (1) General background information; (2) Identification of major risk factors affecting the performance of highway construction infrastructure projects in Nigeria; and (3) Investigation of risk management processes and techniques currently used in highway infrastructure construction projects in Nigeria and their effectiveness. Detailed interview questions can be found in Appendix 4.

7.2 Procedure for the analysis of the interviews

All the interviews were recorded and transcribed and analysed using the qualitative analysis software package NVivo-11. A thematic analysis technique was used in the following steps: creating a project; importing the interview transcripts; exploring data with queries such as text search and word frequency; creating nodes (e.g. labelling, describing); creating node classifications and attributes e.g. demographic data; creating case nodes and connecting them to case classification and use queries and exploring functions. The use of NVivo allowed the researcher to sort through the data while at the same time enabled exploration of patterns and recurring phenomena. This allowed the researcher to compare, contrast and synthesise. The data were coded under appropriate headings that were sorted to produce cross-case comparisons.

7.3 General background information

Thirteen interviews were conducted with participants from 4 selected highway projects located in the Central, South-East and South-West regions of Nigeria designated as: project 1(Abuja-Lokoja); project 2 (Enugu-Port Harcourt); project 3 (Lagos- Badagry); and project 4 (Lagos-Ibadan) highways respectively. The thirteen participants were chosen on the grounds of their designation and extensive experience in highway infrastructure construction projects in Nigeria. Each interview lasted between 50 minutes to 1hr 30 minutes. Table 7-1 shows the background information of the interviewees. For confidential reasons, personal details are kept secured by the

researcher for any follow up. The interviewees comprise 4 government representatives (the client), 6 contractors and 3 consultants,

Table 7- 1: Background information of the interviewees

Case studies	Interviewee code	Designation	Years of working experience in highway projects
Abuja-Lokoja	CN1	Deputy director, government	More than 20 years
	CN2	Chief resident engineer, consultant	More than 15 years
	CN3	Project manager, contractor	More than 11 years
Enugu-Port Harcourt.	SE1	Project engineer, government	More than 12 years
	SE2	Project consultant	More than 8 years
	SE3	Project manager, contractor	More than 15 years
Lagos-Badagry	SWA1	Deputy director, government	More than 24 years
	SWA2	Site engineer, contractor	8 years
	SWA3	Project engineer, contractor	10 years
	SWA4	Resident engineer, consultant	18 years
Lagos-Ibadan	SWB1	Project engineer, consultant	More than 10 years
	SWB2	Project manager, government	More than 15 years
	SWB3	Site engineer, contractor	More than 5 years

7.4 Background information regarding the selected highway construction projects in Nigeria

Case 1: Dualization of Abuja-Lokoja Road Section III: Abaji to Kotonkarfi towns, Nigeria

The Abuja-Lokoja road is a major link between the Northern and Southern parts of Nigeria. It is one of the major routes used in transporting imports/exports, industrial and agricultural products. The whole Road project was divided into four sections: Section 1 (International Airport Link Road-Sheda Junction, 42-kilometre span); section 2 (Sheda Junction – Abaji Road, 52.55-kilometre span); section 3 (Abaji - Kotonkarfi towns, 49.36-kilometre span); and section 4 (Kotonkarfi – Lokoja Road, 50-kilometre span). Contracts were awarded for each of the sections to different contractors in 2006 at the contract sum of N42 billion (approximate US$300 million) for the total length of 196 km.

Section 3 (Abaji - Kotonkarfi towns), which was awarded to Bulletine Construction Co. Ltd at the contract sum of N9.7billion, was selected as one of the case studies. The contract involves the construction of new carriageway as well as the rehabilitation of the existing one. It consists of wearing course, binders, lined drains, bridge works and culverts. It is funded by the Federal Ministry of Works and Housing through federal budgetary allocation. The project adopted competitive bidding through the traditional

procurement method. The project was awarded in 2006 which had initially two and half year's duration but up until the time of writing it is still on-going, as shown in Figure 7-1.

Figure 7- 1: Reconstruction of Abuja-Lokoja highway section III: Abaji to Kotonkarfi towns, Nigeria

Case 2: Rehabilitation Enugu Port Harcourt Expressway

The contract for the entire rehabilitation and reconstruction of highway between Lokpanta and Umahia, a 59.5km span along the Port Harcourt Expressway, was awarded to Setraco Nigeria Limited at the contract sum of N39.6 billion. This project has drawn the attention of the federal government because it has been in a deplorable state over the past two decades. It is funded by the Federal Ministry of Works and Housing through the federal budgetary allocation. The project adopted competitive bidding through traditional procurement method. The federal government acts as the project client. The project was awarded in 2013, with three and a half year's duration. The project has suffered some setbacks due to lack of funds to pay contractors. It is now in progress, as shown in Figure 7-2.

Figure 7- 2: Rehabilitation of Enugu Port Harcourt Expressway

Case 3: Rehabilitation of Lagos-Badagry Expressway

This project involves the expansion of the existing road; a 4-lane dual carriage road of approximately 60km into a 10-lane road and two rail lines. The road had been in existence over the past 50 years and was in deplorable condition. It links Nigeria with neighbouring West African countries (Benin Republic and further to Togo and Cotonu). It is a business and commercial route. The reconstruction of the project is in three lots: Lot 1 (the Eastern section of the road) has a 7.20 km span, starting from Eric Moore to Mile 2); Lot 2 consists of the Central Section (24.5 km span), to start from Mile 2 to Agbara, and Other Lots (the Western Section) a 28.57 km span from Agbara to Badagry).

The first phase, Lot 1, was completed by Julius Berger Nigeria Plc, but behind schedule. The second phase, Lot 2A, of the project was awarded to Chinese Civil Engineering Construction Company (CCECC) at the contract sum of N100 billion. It adopted competitive bidding through the traditional procurement method. It is a World Bank assisted project in collaboration with Lagos state government funding. The project started in 2012 with a 4-year completion period. The project is still on-going and is planned to be completed before the end of 2019. The delay was attributed to difficulty in the relocation of pipes and cable that belonged to the Nigerian National Petroleum Corporation (NNPC) and some delay in funding. The progress of the project is shown in Figure 7-3.

Figure 7- 3: Rehabilitation of Lagos/Badagry Expressway

Case 4: Rehabilitation of Lagos/Ibadan Express Road

This is a 127.6 km expressway that connects Ibadan (Oyo state capital) and Lagos (Nigerian largest city). It is among the oldest expressways in Nigeria and is the primary route to the Northern, Southern, and Eastern regions of Nigeria. The contract for the rehabilitation, reconstruction and expansion of the expressway was awarded to Julius

Berger Nigeria Plc and Reynold Construction Company Limited in April 2014 at the contract sum of N170 billion. It is funded by the Federal Ministry of Works and Housing through federal budgetary allocation. The project adopted competitive bidding through the traditional procurement method but later changed to public private partnership, in April 2015. The federal government act as the project client. The project was scheduled to be completed in November 2016 but as of now it is said to be 40% completed. Its progress as of the time of data collection is shown in Figure 7-4

Figure 7- 4: Reconstruction/Rehabilitation of Lagos/Ibadan Expressway

7.5 Identification of major risk factors affecting the performance of highway infrastructure construction projects in Nigeria

The interview questions used for this section were:

Interview question 2.1: Are there any risk factors affecting the performance of this project, based on your experience and responsibility within the highway infrastructure construction in Nigeria? Please explain.

Interview question 2.2: Please tell me about the consequences (impacts) of each of the risk factors identified above on the performance of this particular highway infrastructure construction project. (Hint: use very high, high, medium, low and very low to explain.

7.6 Interview results and discussion of risk identification

In all, 19 risks were identified from the interviews that are associated with these case study projects in Nigeria. Risks associated with each of the cases are summarized in Table 7-2. It should be noted that the general perspective was investigated through the survey, while the interview results are specific to the 4 case study projects.

Among the 19 risks, 9 risks were found to be common to all the selected four cases of highway projects. These risks included: change of government, corruption, cost of construction materials, cost of labour, exchange rate fluctuations, inflation, political interference, project funding challenge, construction time delay. The remaining 10 risks differed in one or more of the selected 4 cases, as seen in Table 7-2: for example, adverse ground condition occurred in case 1; community restiveness in cases 2 and 4; defective design in case 4; environmental risk in cases 3 and 4; health and safety risk in cases 3 and 4; inclement weather in cases 2, 3 and 4; land acquisition problems in cases 3 and 4; material quality in case 3; terrorism in cases 1, 3 and 4 and theft and robbery in cases 2 and 3). The reason for the existence of adverse ground conditions in case 1 compared to the projects in cases 2, 3 and 4 was as a result of their differences in geological and topographical setting. The unstable subsoil, high water table, rock outgrowths and subterranean rock formations associated with some sections of the case projects accounted for these differences. Community restiveness is prevalent in cases 2 and 4 due to their location within the commercial city and the oil region of Nigeria. The unemployed youth within this region constitute this risk. Health and safety risks are mentioned in cases 3 and 4 as a result of their commercial nature and congestion within these project locations. The predominance of inclement weather in cases 2, 3 and 4 compared to case 1 is as a result of the varying climatic conditions in Nigeria. The cultural differences due to diverse ethnic groups within Nigeria accounted for some of the differences in risk occurrence within the different cases, as seen in Table 7-2. It is interesting to note that all the 9 risks found to be common to all the selected cases are the top nine risks identified from the quantitative analysis results in Chapter 5. Hence, these findings validate the findings of the questionnaire analysis through quantitative studies.

The interview results concerning the nine risks common all the 4 cases of the selected highway projects are discussed in the next section.

Table 7- 2: Interview results of risks associated with 4 cases of highway infrastructure construction projects in Nigeria, extracted from the Nodes Matrix of NVivo output

Identified risks	4 Case study projects			
	Abuja-Lokoja	Enugu-Port Harcourt	Lagos-Badagry	Lagos-Ibadan
Adverse ground condition	✓			
Change of government	✓	✓	✓	✓
Community restiveness		✓		✓
Corruption	✓	✓	✓	✓
Cost of construction materials	✓	✓	✓	✓
Cost of labour	✓	✓	✓	✓
Defective design				✓
Environmental risks			✓	✓
Exchange rate fluctuation	✓	✓	✓	✓
Health and safety risks			✓	✓
Inclement weather		✓	✓	✓
Inflation	✓	✓	✓	✓
Land acquisition problems			✓	✓
Material quality			✓	
Political interference	✓	✓	✓	✓
Project funding change	✓	✓	✓	✓
Terrorism	✓		✓	✓
Theft or robbery		✓	✓	
Time delay	✓	✓	✓	✓

✓ Indicates occurrence of risk factor on the case project

7.6.1 Change of government and political interference

Change of government and political interference are political risks and they both fall under the broad classification of external risk factor. All the interviewees identified political risks as a serious type of risk affecting the construction of highway infrastructure construction projects in Nigeria. Interviewee CNI put it in this way: '*Another issue in this project is change of government. Each time a new government comes in to power it will delay the project as they have to settle down before thinking of commencing any project. The project has witnessed three different regimes yet it is still on-going. It is one of the major problems'*. Interviewee CN2 mentioned that they are always delaying project execution during the transition from one government to another. Interviewee SEI put it in this way '*Once there is a change in government, every project comes to a halt, waiting for the decision of the new government'*. Interviewee SWB1 responded that '*whenever there is a change in government, on-going projects will be delayed and, as a consequence, inflation and interest rate fluctuation*

will follow, resulting in a sharp rise of labour and material costs. This is the experience of this project now'. According to interviewee SWB2, *at the time of general election, work was temporarily suspended waiting for the new government to settle in office. Thus it takes some time for construction activities to be normalised*. The interview findings show that government-funded projects such as highway construction projects suffer high political risk, as a result of political uncertainty and its influence on the on-going project.

7.6.2 Corruption

The Corruption Perceptions Index (CPI) reported by Transparency International has shown that official corruption is prevalent in Nigeria and it ranks as the 136th least corrupt nation out of 175 countries (Rose-Ackerman and Palifka, 2016). Accordingly, the average perception corruption rank in Nigeria was found to be 119.14 from 1996 until 2016, attaining a peak of 152 in 2005 and a record low of 52 in 1997. In May 2016, the then British Prime Minister was heard to describe Nigeria and Afghanistan as 'fantastically corrupt' (Asthana & Grierson, 2016). The Nigerian government recognised this fact and as such is putting all measures in place to curb corruption in Nigeria. All of the interviewees in all four case study projects recognised the existence of corruption but declined to comment further, for personal reasons. Interviewee SE3 asserted: '*Corruption is so endemic in Nigeria and is a major problem experienced in this project*. Compared to less corrupt countries, execution of highway infrastructure construction projects in Nigeria is exposed to high level of corruption risk'.

7.6.3 Cost of construction materials and labour

The 13 interviewees recognised the existence of cost of construction materials and labour risks in all the case studies' projects. The peculiarity associated with the Nigerian economy is the rate at which price of goods and services continue to rise. Interviewee CN1 explained that *rise in the price of construction materials e.g. bitumen, diesel, cost of labour, had negatively affected the progress of this project.* Interviewee SE3 responded in this way: '*Price of construction materials and cost of labour continues to rise sharply every day and this too have high negative effect on this project. Because money is not available when needed, it will result in delays and even cost overrun of the entire project*'.

7.6.4 Exchange rate fluctuations

These risks are all grouped under economic risks that fall under the main classification of external risk factor. Nigeria is significantly different from many countries due to its volatile exchange rate and inflation. All the interviewees commented on the high rate of inflation in Nigeria and stated that it had affected each of the highway projects they had been involved in. The exchange rate between both the US Dollar (USD) and Nigerian currency and GBP and Nigerian Currency has been very unstable since the present administration took over the government in May 2015. For example, most of the interviewees mentioned that inflation has a high impact on their projects as the price of materials and labour keep on increasing and the contractor will have to request a review of the contract terms. The interviews indicated that highway infrastructure construction projects in Nigeria are exposed to high exchange rate fluctuations and inflation.

7.6.5 Project funding challenge

The challenge of project funding is classified as a financial risk and falls under internal risk factors. The interviewees stressed the special case in Nigeria that projects initiated by the previous government face the risk of delay by their successor. The interviews revealed how a change of government leader determines how projects receive priority funding in different geo-political zones. This is consistent with the finding of Baloi and Price (2003) that project funding in developing countries seems to be political in nature. Interviewee CN1 cited insufficient funds as one of the major risks on this project and *commented that this project was being funded by the federal government, but from the start of the project sufficient funding had not been allocated to it*. Interviewee SE1 expressed his view in this way: '*One of the major challenges facing this project is inadequate supply of fund. There has not been sufficient money dedicated to the project. Contractor will only work once there is money; but once the flow of cash stop, work will be stopped until they are paid again'*.

7.6.6 Construction time delay

All of the interviewees recognised the existence of this risk and revealed how this risk occurred as a consequence of some of the above risks. For example, interviewee SE1 explained that the price of construction materials and cost of labour continued to rise sharply every day and this too had a high negative effect on this project. Because money is not available when needed, it will result in delay and even in cost overrun. Interviewee CN2 stated that, '*Lack of funding has also resulted in time overrun, which*

will have also contributed to cost overrun. The inflation which resulted in increase of price of labour and construction material has also led to cost overrun of this project. The project is still on-going but it could pick up as soon as the new government have settled'.

7.7 Interview results regarding the consequences of the identified risk

The interview question under this section requested the interviewee to comment on the consequence of each of the identified risks on the performance of the project that they were involved at the time of the interview. The interviewee identified each of the nine risks above common to the all the case studies as having major consequences on the performance of highway infrastructure construction projects in Nigeria. For example, interviewee CNI explained that each of the above risks mentioned has a high impact on the project he was involved in. He further stated that *lack of funds had resulted in the contractors abandoning the project on two different occasions, due to lack of payment*. This project had been abandoned before the contractors were called to the site and it had been stagnated for a while at the time of the interview. Inflation has had a strong impact on this project, as the price of materials and labour kept on increasing and the contractor would have to request a review of the contract terms. The changes in government had also had high impact on this project. Since the new government came into power, there had been challenges in paying the contractor for the job they had done.

Interviewee SE2 stated that *an inadequate supply of funds had had a serious impact of slowing down the speed of construction of the project. There was no steady flow of cash for this project and the recent transition to a new government had also contributed to the delay of the project*. Interviewee SWB1 responded that the effect of project funding and political instability was really high in this project. The transition from one political party to another had really slowed down this project.

7.8 Interview results regarding risk management processes and techniques currently used in Nigerian highway construction projects and their effectiveness

This section presents the findings from the interviews regarding risk management processes and the techniques currently used to manage risk associated with highway construction projects in Nigeria. The interview questions and the interviewees' responses are presented and discussed below.

7.8.1 Interview results regarding current risk identification processes used in Nigerian highway projects

Question 3.1: Did you at any stage of this project identify the potential risks that might affect its performance? If yes, please tell me more about the different stages of this project in which you have identified the risks

The essence of this question is to understand whether risk identification was actually carried out on the case study project and to what extent. Table 7-3 shows the exported Node Matrix (NVivo output) of the stages of risk identification revealed from the interview of 4 cases of Nigerian highway projects.

Table 7- 3: Interview result of exported Node Matrix of the stages of risk identification stages in 4 cases of highway projects in Nigeria

	Abuja-Lokoja	Enugu-Port Harcourt	Lagos-Badagry	Lagos-Ibadan
Feasibility stage	3	5	4	5
During tender	0	3	2	0
Project execution stage	3	3	4	3
Project completion stage	0	0	2	3

All the 13 interviewees agreed that they performed risk identification at the feasibility stage, and during the tender, project execution and project completion stages. As revealed by the interview results shown in Table 7-2, the risk identification stage was

not uniform across the 4 cases of the highway projects. This could be due to different management strategies across the 4 cases of the project. For example, in the Abuja-Lokoja project, risk identification was performed only at the feasibility and project execution stages. In the Enugu-Port Harcourt project, however, they did not see need for risk identification at the completion stage of the project, while in the Lagos-Ibadan project they had not given priority to risk identification at the tender stage of the project. Only in the Lagos Badagry project was it considered necessary to perform risk identification at all the stages identified by the interviewees. This could be because this project is a World Bank assisted project.

In response to the above interview question, interviewee CN3 responded, '*At the feasibility stage of this project we identify some of the key risks in this project and as the project implementation stage we keep on looking at some possible risks that might slow it down but managing them is challenging due to lack of support from everyone involved'*. Interviewee SE2 simply put it: '*Risks are being identified before the award and during the execution of this project'*. Interviewee SWA1 put it in this way: '*We identify risks prior to, during and after the construction process*es. Interviewee SWB1 claimed that '*Risk has always been given attention right from the start of this project. It is on-going and will continue to the completion stage of this project'*

The interviews clearly showed that risk identification was being performed at the different stages of the highway construction projects in Nigeria but, as revealed by some of the interviewees, the problem was not in risk identification but in management, which was due to lack of support of key project stakeholders.

Question 3.2: Do you keep record of the identified risks? How?

Table 7-4 shows exported Node Matrix from the NVivo of the response to this interview.

Table 7- 4: Risk record keeping methods in Nigerian highway projects

	Abuja-Lokoja	Enugu-Port Harcourt	Lagos-Badagry	Lagos-Ibadan
Risk file	2	0	0	0
Risk record sheet	0	0	0	2
Risk register	2	5	1	3
Routine report	0	0	3	1

In the Abuja-Lokoja project, two interviewees each mentioned risk file and risk register as methods of keeping records of identified risk. According to interviewee CN3 '*We have a file for keeping record of the risk in this project which we update regularly in our weekly project team meeting. The documentation process of risks in this project is poor'*. On the other hand, interviewee CN2 responded, '*We have project risk register where we keep record of all identified risks. This we updated regularly during project management board meetings*'. Interviewee CN2 was from the consultant part of the project while interviewee CN3 was from the local contractor working on the project. It seems that the consultant had better risk record-keeping compared to the local contractor in this project. In the Enugu-Port Harcourt project, they solely used a risk register as the risk record-keeping method. Interviewee SE1 had this to say: 'We have project risk register where we record all the identified risks in this project. We review the risk register every two weeks when the project management board meet'.

In the Lagos-Badagry project, a combination of risk register and routine report was mentioned as the risk record keeping method while in the Lagos-Ibadan project, a combination of risk record sheet, risk register and routine report was mentioned as the method of risk record keeping

Question 3.3: Tell me about risk identification tools and techniques you have always used in identifying risks in this project

Table 7-4 shows the exported Node Matrix from the NVivo of the current risk identification tools and techniques mentioned in response to the above interview questions. As shown by the interview results in Table 7-4, the interviewees in the central Nigeria highway project mentioned brainstorming, experience from previous projects, expert judgement and risk checklists as the risk identification techniques used to identify risk in that project. The interviewee CN3 explained:

> '*We used the experience gained from previous projects to identify risk in this project since most projects here are similar. For example, we have noticed that in previous project, the effect of inflation has resulted in increase in price of construction materials and labour so we use it to predict it as risk in this project. We also noticed how seasonal rainfalls have significant negative impact on other past project so we tried to avoid any serious construction at the time of heavy rainfall. Yes, we do, but these are kept in paper file which can be lost. I must tell you that proper recording keeping is a real challenge for us. We also have some*

detailed list of risks from which we identify which of them are likely to be a risk in this project. In our project management team meeting, individual team members generate idea of risks that might have negative impact on the project. This is a kind of brainstorming session. We review the lists of risks and then assigned them to risk owner to manage. We do this twice in a month and sometime once in month due to some unforeseen circumstances'.

Table 7- 5: Interview result from exported Node Matrix of current risk identification tools and techniques in Nigerian highway projects

	Abuja-Lokoja	Enugu-Port Harcourt	Lagos-Badagry	Lagos-Ibadan
Brainstorming	1	3	4	4
Experience from previous projects	5	3	0	0
Expert judgements	1	4	4	4
Historical data	0	0	0	0
Risk checklists	3	0	0	0

From the responses of the interviewees shown in Table 7-5 in the Enugu-Port Harcourt projects, combinations of brainstorming, experience from previous projects and expert judgements were used to identify risk in those projects. In the Lagos-Badagry and Lagos-Ibadan projects, combinations of brainstorming and expert judgements were used to identified risks in those projects. Expert judgements and brainstorming were mentioned by all the interviewees as risk identification techniques. From the questionnaire analysis these techniques were also identified as the two most often used risk identification techniques with consulting experts ranked first followed by brainstorming; this correspondence validated the result of the quantitative analysis of risk identification techniques.

Question 3.4: How did you use the above techniques? (E.g. periodical risk review meeting)

In response to this question, interviewee SWA4 responded, *'Brainstorming and expert judgement were used in weekly site meetings to review the identified risks associated with this project'*. Similarly, SWA2 reported, '*Consultant expert judgement and brainstorming during site visits are used to identify risks in this project'*. According to

interviewee SWB2, '*At the project site meeting, the project director and his assistant, the project manager, project engineer and supervisors were engaged in a brainstorming exercise where each of us generated idea of the possible risk that might affect this project. We then used our expert judgement to review these risks on weekly basis sometime monthly depending on the situation as of then'*. According to interviewee CN1,

> '*In our project management team meeting, individual team members generate idea of risks that might have negative impact on the project in a form of brainstorming session. The lists of risks are reviewed by our expert and then assigned them to risk owner to manage. We do this twice in a month and sometime once in month due to some unforeseen circumstances*.'

The details of the interviews showed that these Nigerian highway project professional identified risks in their project using a combination of risk identification techniques in periodic project team reviews meetings.

Question 3.5: How effective are these tools/techniques in identifying potential risk, from your experience in this project.

In response to this interview question all the interviewees claimed that the techniques they used proved to be effective. For example, interviewee SWB3 said, '*The techniques are very effective and it's evident in the reduction in the occupational hazard/accident elimination of potential hazard and reduction in the general risk level*'. Interviewee CN1 asserted that: '*In my opinion they have been very effective as the severity we attached to them actually confirm the impact of those risks'*. Interviewee SE1 also responded that '*The techniques we used proved to be effective. The challenge is not in identifying the risks but in managing them.*'

7.8.2 Interview results regarding risk analysis process used in the Nigerian highway projects

Question 3.6: Do you still perform risk analysis after the identification process is complete? If yes, how? At which stages?

In response to this question, all of the interviewees reported that they performed risk analysis after the identification process was complete. Interviewee CN3 explained: '*We analysed the identified risks to assess their severity. We do this in our project*

management team meeting by looking at the list of risks previously identified. We do this through the various stages of this project'. Interviewee SE3 said: '*Yes as project engineer, I am actively involved in analysing risks in this project using my expert judgement along with other project team members'.* According to SWB2, *'with the help of expert judgement we analysed the identified risk associated with this project. After reviewing the list of risks the consultants assigned descriptive terms to the identified risk as low, high and medium. The high priority risks were referred for management attention.'*

Question 3.7: Please tell me more about risk analysis tool/techniques you have always used to analyse the identified risk in this project.

In response to this interview, the interviewees mentioned 4 risk analysis techniques that were used in their various projects, as shown in Table 7-6. Across the case study projects, it was found that a combination of qualitative risk analysis alongside expert judgements was used to analyse risk, except that Lagos Badagry, it was mentioned that a combination of all of the techniques were used, as shown in the table. The interviews result again agreed with the finding from quantitative analysis where expert judgement was ranked first, followed by qualitative risk analysis.

Table 7- 6: Interview result for the exported Node Matrix of current risk analysis techniques used Nigerian highway projects

	Abuja-Lokoja	Enugu-Port Harcourt	Lagos-Badagry	Lagos-Ibadan
Computer modelling	0	0	1	0
Consulting expert	3	3	4	3
Qualitative	4	5	1	6
Quantitative	0	0	3	0

Question 3.8: How effective are these tools/techniques from your experience in this project?

There was a consensus among all the interviewees across the 4 cases of highway construction projects in Nigeria that the risk analysis techniques used proved to be effective.

7.8.3 Interview results for risk response strategies used in the Nigerian highway projects

Question 3.9 & 3.10: How did you respond to the risks identified and analysed in this project? Please tell me more about risk management actions you have used to respond to risks in this project. From your experience in this project how effective are these actions you have taken toward risks in this project?

Table 7-7 shows exported Node Matrix from the NVivo analysis of the current risk response techniques currently used in the case study Nigerian highway projects in response to the above interview questions. The results show that, in Abuja, a combination of risk avoidance and reducing the possibility of occurrence were used to respond to risks in this project. These techniques were mentioned by each of the interviewees in this project. For example, interviewee CN1 stated:

> '*Risk response action we took includes avoiding the risk as much as we can but it always difficult. Sometime we attempted reducing the possibilities of their occurrences. For example, we tried our best to complete the project on time within the political period but lack of fund is another drawback.*'

Interviewee CN2 stated: '*In this project we attempted avoiding the risks as well as reducing the possibilities of their occurrences. I don't think avoiding these risks is the best option as to me it doesn't prove to be very effective. I think these risks should be properly allocated to the responsible parties capable of managing them'*. Interviewee CN3 stated that: '*risk avoidance is effective if you can, but unfortunately you can't always avoid most of the risk encountered in this project. This means that it is not really effective measure. I think so'.*

There was no mention of risk avoidance in the Enugu-Port Harcourt project but for the Lagos-Badagry and Lagos-Ibadan projects, 3 out of 4 and 2 out of 3 interviewees respectively mentioned using risk avoidance to respond to risk in their projects. In the Enugu-Port Harcourt project, two of the 4 interviewees mentioned reducing the possibility of occurrence and 2 mentioned risk sharing as a means of responding to risk in their projects. In the Lagos Badagry project, combinations of the risk response techniques mentioned were adopted, with the exception of risk sharing. In the Lagos-Ibadan projects, combinations of risk avoidance; reducing the possibility of risk occurrence and risk sharing were mentioned by the interviewees. The risk response techniques employed varied across the different projects in Nigeria, with similarities

among some projects, as shown in the table Thus, although the interviewees agreed that all other risk response techniques they used were effective, they did not agree that risk avoidance is an effective method of responding to risks.

Table 7- 7: Interview result for the exported Node Matrix from the NVivo output of the current risk response techniques used in the Nigerian highway construction projects

	Abuja-Lokoja	Enugu-Port Harcourt	Lagos-Badagry	Lagos-Ibadan
Risk avoidance	3	0	3	2
Reduce consequence of occurrence	0	1	2	0
Reduce possibility of occurrence	3	2	3	3
Risk sharing	0	2	0	3
Risk transfer	0	0	2	0

Question 3.11: Do you encounter any barriers or difficulties in implementing risk management in this project? If yes, what are they?

Barriers or difficulties mentioned by the interviewees in implementing risk management in their projects were: information sharing problems, lack of committed resources, lack of joint risk management mechanisms, lack of support from key stakeholders, and language and communication barriers. Interviewee SWA4 explained:

> '*We faced many challenges in an attempt to perform risk management on this project some of which are: attitude of the general stakeholder including the general public and difficulty in information sharing; Lack of support from some key stakeholder is another drawback in this project to perform risk management. Sometime information is not released on time or it is not shared at all or it is not available. Contractors' language barrier is another serious issue in this project'*.

Interviewee SWA1 noted that: '*foreign contractors, the Chinese working on this site has no understanding of Nigerian language and are not fluent in English that is commonly used in Nigeria. This is another challenge for effective implementation risk management practices on this project'*. According to interviewee SE 2: '*Some of the problems faced in performing risk managing in this project are lack of support from*

government, inadequate skilled manpower, lack of resources and lack of joint risk management effort between the different parties'

Question 3.12: How best in your opinion can these barriers be overcome?

In response to this question, three interviewees suggested provision of good information sharing in place; seven of them suggested involvement of key stakeholder participation in risk management activities; five of them mentioned provision of required resources, such as skilled personnel, technologies and money for the implementation of risk management, while eight of them suggested providing training and education on risk management skills development for the project management teams. For example, interviewee SWB2 suggested that: '*The government should emphasize on the importance of risk management and provide training for all the project team for managing risks. There should be committed resources such as personnel, time and finance for dealing with risks'*

Question 3.13: How can each of the major risks identified in 2.1 above be effectively managed to improve the performance of highway infrastructure construction projects in Nigeria?

The management approaches recommended by the interviewees in response to this question are summarised in Table 7-8.

Table 7- 8: Interview results showing the risk management approaches recommended by the interviewees for the major identified risks.

Risk identified by the interviewees	Interviewees	Management approaches recommended by the interviewees
Change of government	CN1 & CN2 (case 1):	Good legal system in place to guide against political interference;
	SE1 & SWB3 (cases 2 & 4):	Provide insurance against political risks;
	SE2 & SWB1 (cases 2 & 4):	Provide legal systems that allow continuity of any on-going projects irrespective of changes in government;
	CNI, CN3, SWB2 & SWB3 (cases 1 & 4):	Proper allocation of the risks to the right party.
Political interference	Interviewees SE2 & SWB1 (cases 2 & 4):	Get insurance against any political risks;
	Interviewees SE1, SE2 &SWB1 (case 2&4):	Establish partnership with domestic partners such federal government agencies;
	SE1 (case2):	Provide employment for the local resident;
	SE3 (case 2):	Provide maximum security and provide job for the agitated youths within the surrounding communities;
	SWA2 (case3):	Terrorism/kidnapping can be managed by providing security to reduce the risk.
Corruption	CN1, CN2 & SE1 (case 1 & 2):	Effective monitoring and control to ensure that project money is used correctly for the project;
	SE2 (case 2):	Encourage partnering of local and international contractors;
	SE3 (case2):	Proper orientation and attitudinal changes as we are now witnessing from the government at the central level is a way of managing this risk;
	SWB3 (Case 4):	Project monitoring team should be established to continuously monitor project activities through the duration of the project;
	SWA1 & 3 (case 4):	Continuous awareness training to key management personnel to deal with corruptions
Cost of construction materials and labour	CN2, SWA2& SWA3 (cases 1 & 3):	Establish a clear, suitable plan and control schedule and cost;
	SE1 & SE2: (case 2):	Engage reputable local suppliers and labour to reduce cost;
	SWA1 (case 3):	Provide security package (e.g. material and labour bond) to guide against cost overrun;
	SWB2 & SWB3 (case 4)	Establish independent project monitoring team to control progress and quality
Exchange rate fluctuations	CN1, CN2, CN3, & SWB1 (cases 1 & 4):	Ensure adequate cash reserve for working capital;
	SWA1 (case 3):	For exchange rate and unstable government, it is difficult to explain how to manage these risks;
	SWB3 (case 4):	Proper allocation between the client and the contractors
Inflation	CN1, CN3, SWB2 & SWB3 (cases1c&c4):	This risk should be properly allocated between the contractors and client by contractual provision;

	SWB3 (case 4):	Proper allocation between the client and the contractors
Project funding challenge	CN1, CN3 & SWB1 (cases 1 & 4): CN2, SE2 & SWB1 (cases 1, 2 & 4): SE2 & SWB1 (case 2&4)	Ensure sufficient funds before project commences; Government should not embark on any project they cannot afford to complete; Legal system in place to ensure that project funds are used accordingly
Construction time delay	SWA3 (case 3): SWB1, SWB2 & SWB3 (case 4):	Establish a clear, suitable plan and control on schedule and cost; Establish independent project monitoring team to control cost and quality.

7.9 Chapter summary

This chapter has presented the qualitative data analysis of the research using 4 cases of on-going highway infrastructure construction projects in Nigeria. The interview results regarding the risks associated with each of the selected cases of the highway projects were presented and it was established that the results for the identified risk validated the results obtained for the critical risks using quantitative analysis. The results regarding the risk management processes adopted in each the four cases of the highway projects in Nigeria were also presented, together with the interviewees' recommendations for the management of the major risks identified. The findings from this chapter together with those of the previous chapters will be used to develop the risk management framework presented in the next chapter.

Chapter 8: Framework Development

8.1 Introduction

This chapter presents the development of a risk management framework for highway construction projects in Nigeria. The framework aims at improving the management of key risks in Nigerian highway construction projects in order to improve their performance. It is the based on the synthesis of the findings from the previous chapters alongside the result of the literature reviews. Thus is comprises the amalgamation of the best practices obtained through comprehensive literature reviews and the research findings.

8.2 Rationale for the development of the risk management framework for highway construction projects in Nigeria

The research findings from the questionnaire survey (Chapters 5 & 6) and case study of four highway construction projects in Nigeria (Chapter 7) clearly show that risk management in Nigerian highway construction projects is often dealt with inadequately and that Nigerian highway construction practitioners are not satisfied with the way highway construction projects are being managed. Previous studies have shown that poor risk management is one the major reasons for poor quality; cost and time overrun. Furthermore, poor risk management is recognised by the World Bank as being responsible for delays in many partnered infrastructure projects (Zhang, 2005). Similarly, one of principal reasons for unsuccessful highway project delivery in Nigeria is lack of systematic risk management.

Numerous risks exist throughout the life cycle or phases of construction projects and they differ according to the project type, the contract involved and the procurement route. This research focuses mainly on the construction phase of highway projects in Nigeria. Managing risks during the construction phase of a highway project could be as important as, if not more important and complex than risks in the other phases. Moreover, highway projects have been noted as being among the most risky construction projects, as a result of their long construction duration, quality concerns and possible cost overrun (Hashem & Guggemos, 2015).

The interviews with the highway professionals found that there is currently no widely adopted risk management framework for highway infrastructure construction projects in Nigeria. The main aim of this study is to develop such a risk management framework which can provide guidance for the Nigerian highway construction practitioners: clients, contractors and consultants to manage key risks associated with the construction of highway infrastructure projects, especially during the construction phase.

8.4 Development of the risk management framework for the Nigerian highway construction projects

To develop a comprehensive framework, it is most logical to build on an existing framework (Bassioni et al., 2005). Different principles may be adopted for the development of a comprehensive framework. This research has employed the following key principles for the development of the framework:

- Reviewing existing research, ideas and concepts of highway project risk management;
- Synthesizing the existing literature on project risk management; risk management processes and techniques;
- Using appropriate data collection methods;
- Building on existing risk management frameworks, instead of 'reinventing the wheel';
- Making use of existing risk management tools that are successfully used in other countries and;
- Aiming to provide practical guides for professionals working on highway projects in Nigeria.

Following the review of risk management processes presented in Table 3-1, a general risk management framework was developed, as shown in Figure 3-2. The proposed framework (Figure 8-1) follows the pattern of the general risk management framework and consists of five distinct phases: risk management planning, risk identification, risk analysis, risk response planning, and risk monitoring and review. The task definitions for each of these phases are based on a questionnaire survey and case study findings of this study as well as findings from literature review. They are described in the following sections.

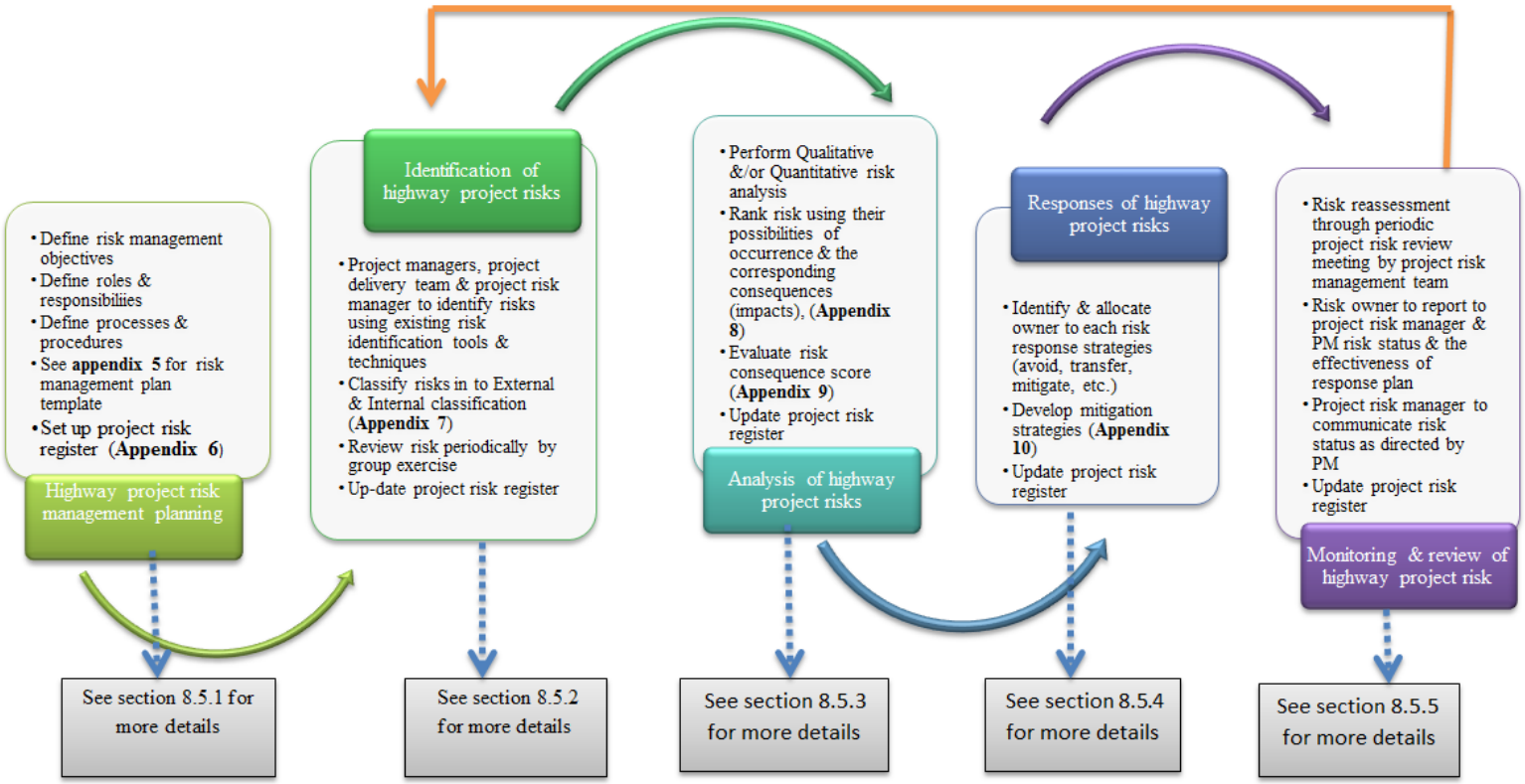

Figure 8- 1: Risk management framework for highway construction infrastructure projects in Nigeria

8.5 Guidelines for the Application of the Framework

The highway risk management framework guidelines discussed here mainly aim to ensure effective management of highway project risks in Nigeria during its construction phase, but could also be applied during the whole project life cycle (from inception to completion phase). These guidelines offer information to project managers and project teams, including clients, contractors and consultants, with their risk management responsibilities in the following ways: providing a reliable approach to undertaking project risk management tasks; providing techniques and tools for highway project risk management; and providing guidance on how to pre-emptively respond to risks. The framework consists of five phases as discussed below.

8.5.1 Highway project risk management planning

The first phase of the framework lays out how to approach, plan and implement risk management tasks for highway construction projects. This phase enhances the possibility of success for the other phases of the framework. The project manager takes the responsibility for and approval of the project risk management planning with the support of the project team members and the agreement of the project sponsor. The risk management planning yields the output or deliverable, referred to as the risk management plan (RMP), which states how risk management will be performed for the project. It is worth noting that the RMP does not contain any identified risks nor their corresponding response actions. The RMP of the proposed framework consists of, but is not limited to the following elements:

- **Risk management methodology**: States the approaches, tools, and data sources that could be used to undertake risk management on the project. It mainly explains how to approach, plan and implement all activities regarding risk management for a particular highway project in Nigeria. The purpose of the framework's risk management approach is to deal with threats (the negative consequence of the project risk). (See appendix 5 for more details).
- **Roles and responsibility**: This section specifies the task of the project team members regarding their responsibilities for each of the risk management activities in the RMP. (See appendix 5 for further details).

- **Budgeting**: This section explains how to allocate resources and estimate funds required for the management of risk by the project risk management team for the entire project (see appendix 5 for more details).
- **Schedule of project risk management meetings:** States when and how frequently the risk management process is to be undertaken for the project at each point in time.
- **Risk reporting format:** States how the results of the risk management processes will be documented analysed and communicated to the key project stakeholders. It is recommended that a copy of the risk register template should be attached to the risk management plan.
- **Tracking:** States the process to be followed to track identified risks and recognise occurrence of new risks that are likely to affect the project delivery success. It also documents how risk activities will be recorded for the benefit of the current project as well as for future needs and lessons learned**.**

See **Appendix 5** for a sample of risk management plan template.

The project manager, project sponsor and project team members should co-operatively develop a risk register that will enable them to identify, analyse, and prepare a response to monitoring and reviewing highway project risks. See **Appendix 6** for a sample of the highway project risk register template. The risk management planning should be completed during the planning phase of the project, as it is essential to the successful conduct of the other phases of the framework.

8.5.2 Identification of highway project risks

The purpose of the risk identification phase of the framework is to capture the key potential risks that might adversely affect the objectives of the project. It produces the deliverable or output called the project risk register (where risks are identified that could affect the project performance to achieve its objectives). The risk register is successively amended with the results from qualitative risk analysis and risk response planning, and is reviewed and updated throughout the project phases. The risk register is a tool (generally a spreadsheet) that can be used by the project teams to report and record project risks throughout the project phases (Patterson and Neailey, 2002, PMI, 2008, Caltrans, 2012). It is a useful tool that communicates project risks and assists the team members to comprehend the status of the project risk as it passes from conception to completion phase.

Project delivery success can be improved by setting up and keeping a risk register over the lifecycle of a project. The risk register ensures that project risks, analysis and responses are communicated through the project phases so that risks are known, understood and effectively managed.

A Nigerian highway project risk management team comprising of project managers, the project risk manager and the project delivery team (e.g., contractors, client, consultant) should use any combination of checklists, brainstorming, historical data, interviewing, consulting experts (discussed below) to identify potential risks that might affect the objectives of the project at its stage of development. Although risk identification is a collective team responsibility, the project manager is primarily responsible, with the support of the project risk manager and the project team member agreed by the project sponsor. The results of the potential risks identified should be categorised and grouped, as done in the questionnaire (**Appendix 7).** The information should be entered into the risk register. A risk owner should be assigned to each risk from the project risk management team and the project risk register should be reviewed and updated throughout the project.

A number of tools and techniques are available for identifying highway construction project risks (Table 3-2, Chapter 3). Based on the research findings (questionnaires, case studies interview) and literature reviews, the following techniques are recommended in the framework.

8.5.2.1 Checklist

A risk identification checklist can be generated using historical information and knowledge that has been gained from previous similar projects and other sources of information. It can be developed by an expert risk manager or small group of representatives from all the disciplines of the highway project. The risk categorization framework in **Appendix 7** can be used as a checklist for Nigerian highway construction projects. When a project is completed, the checklist is reviewed to include new lessons learned and improve it for use on impending projects. The risk management team should also endeavour to explore items that are not on the checklist. This is an easy technique to use at the basic level.

8.5.2.2 Brainstorming

Brainstorming aims at generating a comprehensive list of risks that might affect the project objectives either negatively or positively. It's among the leading and most

extensively used techniques for risk identification. In a brainstorming session, ideas regarding project risks are generated under the governance of a facilitator in an intensive group exercise. The highway project delivery team, including contractors, client, consultant, project manager and the project risk manager can perform the brainstorming with the project risk manager acting as the facilitator. Risks are then identified and categorised as shown in **Appendix 7**.

8.5.2.3 Consulting expert

An expert with relevant experience of risk management of similar projects can be consulted to identify risks that might affect the performance of the highway construction projects. The project manager should identify such experts and engage them to assess all aspects of the project and propose possible risks based on their previous experience and field of technical know-how.

8.5.3 Analysis of highway construction project risks

Risk analysis connotes evaluating the identified risks, and assessing their respective possibilities and consequences. It produces the deliverables referred to as risk register updates. It can be performed either qualitatively or quantitatively as the situation demands. This phase of the framework suggests that qualitative and/or quantitative risk analysis should be performed to evaluate each of the identified risks for further actions (response). It should be clearly stated in the RMP which of the approaches is to be used. Based on the research findings (questionnaires, case studies interview) and literature reviews, qualitative analysis is recommended for this study. The reason being that quantitative risk analysis involves sophisticated techniques (e.g. Monte Carlo Simulation, Sensitivity Analysis), is costly, and requires significant expert effort to conduct. Risk management is relatively new in the Nigerian construction industry, there is shortage or lack of resources (expert personnel, software for performing numerical techniques involved in quantitative risk analysis); hence, it is not a suitable option. The responsibility of risk analysis principally lies with the project manager, but with the support of the project risk manager and project team members.

A number of tools and techniques are available for the qualitative analysis of highway construction project risks, which are explained in the following subsections.

8.5.3.1 Risk possibility and consequence analysis

The project risk management team members evaluate the possibilities and consequences of the risk occurring and assign descriptive ratings (e.g., 1= very low, 2 = low, 3 =

medium, 4 = high & 5 = very high). **Appendix 8** shows the definitions of risk possibility and consequence ratings to be use as a guide for highway construction projects in Nigeria. The ratings are to be used as a reliable frame of reference for the project risk management team in analysing the risks during the life of the project.

Subsequently, the risk criticality is assessed and the risk ownership is assigned to the project team member who will now implement the next phase of the risk management framework, as detailed in the risk management plan following the risk register updates.

8.5.3.2 Risk Possibility & Consequence Matrix

Identified highway project risks should be analysed qualitatively to determine their possibility of occurrence and the corresponding consequences on the project objectives. The essence is to limit the analysis of the project risks to those that are more critical, for example, those that have high impact on the key project objectives, such as time, cost, quality and scope. High possibility/severe consequence risks are then prioritised for further action. This will enable the performance of highway construction projects to be effectively improved by directing effort toward high priority risks.

The principal technique for doing this is the Probability & Impact Matrix (Possibility & Consequence Matrix) where the possibility of the occurrence and the consequences of each risk are assessed against their stated scales. The risk matrix in **Appendix 9** should be used as a guide to determine the significance of each risk consequence based on the possibility and consequence ratings.

For a certain consequence, the totality of the possibility rating of the risk occurring and the consequence rating puts the risk into one of the three coloured zones in the risk matrix. The colour of the zone shows the priority of the risk for risk response: red zone signifies high importance, yellow is medium importance, and blue is low importance. The aggregate of the possibility number and the consequence number defines the risk score, e.g. a risk having medium possibility and a high consequence is in the red zone and its consequence score is 12.

8.5.3.3 Expert Judgement

The expert panel plays an important role in assessing the possibility and the consequence of each risk, to determine its location in the matrix shown in **Appendix 9**. Experts are mainly those with experience in similar projects that occurred in the past.

The project managers, project risk manager and other members of project risk management team can all play a part in the expert panel.

8.5.4 Risk response for highway construction projects in Nigeria

Risk response refers to the process of developing strategic decisions, and defining actions, to enhance opportunities and reduce threats to the project's objectives. The project manager and the project risk owner take the responsibility for project risk response planning, with the support of the project team members and agreement of the project sponsor, and approved by the project manager. In Risk Response Planning a project team are identified and given the responsibility for each risk response. The team project manager's role is to determine which strategies are best fit or most suitable for each risk and then design specific actions to implement the strategy. The essence of the risk response planning phase is to develop responses to the identified risks that are suitable, feasible and reasonable. The deliverables produced from risk response planning include a risk register (updates); project management plan (updates); and project risk management plan (updates) (Caltrans, 2012). These deliverables could result in changes to the contingency reserve (e.g., amount of time or budget required).

8.5.4.1 Risk response strategies

The most common risk response techniques for dealing with project risks are: risk avoidance, risk transfer, risk mitigation and risk acceptance/retention. Risk avoidance attempts to eliminate the risk or to protect the project objectives from its impact. Risk transfer refers to a shift of the adverse consequence of the risk to a third party. Diverse tools exist for this purpose, which include the use of insurance, performance bonds, warranties, guarantees, and incentive/disincentive clauses. An acceptance/retention strategy is adopted in a situation where the possibility of eliminating the risk is not guaranteed or the cost of the response is not justified by the importance of the risk. Acceptance of a risk implies that the criticality of the risk is sufficiently low that nothing will be done about the risk unless it occurs. Mitigation response refers to situation where action is taken on unacceptable risks to reduce either their possibilities or their consequences to a tolerable level. If the possibility or consequence of the risk is reduced, the likely cost of the risk will be reduced as well; therefore, the risk response budget should be reduced.

The framework recommends mitigation strategies for dealing with risks in Nigerian highway construction projects. These mitigation strategies attempt to decrease the

possibility of occurrence or the consequence of an adverse effect of the project risk to tolerable threshold. Just as in the previous phases, the input of expert judgement is also vital in determining what actions are to be taken regarding a specific and defined risk.

The risk management framework proposes mitigation measures for the top 9 critical risks identified in Nigerian highway construction projects (**Appendix 10**) and the project risk register is updated and the process proceeds to the next phase of the framework.

The proposed mitigation measures provided are the results of comprehensive literature reviews and the analysis of the questionnaire survey and case studies in Chapters 5, 6 and 7 respectively. For each of the identified most critical risks, mitigation measures are provided.

8.5.1 Monitoring and reviewing of the highway project risks

The last stage of the proposed risk management framework aims at monitoring the state of the identified risks, identifying new risks, ensuring the appropriate implementation of the agreed responses and reviewing their effectiveness, as well as monitoring changes in the whole project risk exposure as the construction work progresses. The project manager and the project risk owner are responsible for the project risk monitoring and review, with the support of the project risk manager and project team members. It produces the deliverable referred to as the risk register (updates). The output could result in corrective measures and updates to risk identification checklists for future projects (Caltrans, 2012). The project manager should hold risk review meetings regularly (See Risk management plan **Appendix 5**), as suitable, with other project team members at which the risk register is reviewed for the effectiveness of their handling of risks and new risks are discussed and assigned ownership.

Risk rating and prioritization can change during the lifecycle of a project. If an unexpected risk occurs or a risk's consequence (impact) is greater than expected, the planned response may not be adequate. In this case it is recommended that the project manager and the project team perform further response planning to control the risk

8.5.1.1 Risk reassessment

Monitoring and reviewing of risks usually leads to identification of new risks, reassessment of existing risks, and the closing of risks that are outdated. Reassessment of highway construction project risks should be scheduled regularly. The frequency and

degree of the schedule that is suitable depends on how the project progresses relative to its objectives.

8.5.1.2 Review meetings

At the periodic risk review meetings, managing the highway construction project risk should be the main agenda. The frequency of the review meetings depends on the risks that have been identified and their priority. Frequent discussions regarding the risks that affect the construction of a highway project makes it more likely that the project team will identify risks and opportunities.

As can be seen in Figure 8-1, the risk identification process is a continuous process throughout the life-cycle of the project. The framework suggests that risk should be continuously identified throughout the phases of the construction project as new risks emerge. The process ensures that by continually reducing the most critical prevailing risks through mitigation strategies, the overall risk is being reduced continually and systematically. Risk management is not a one-off but an on-going process.

8.6 Chapter Summary

Following the principles of framework development, together with the research findings from the questionnaire survey (Chapters 5 & 6), case studies of 4 cases of on-going highway construction projects in Nigeria (Chapter 7) and the findings from the comprehensive literature reviews presented in Chapter 2 and 3, the risk management framework tailored for highway construction projects in Nigeria has been developed. It consists of five phases which are: highway project risk management planning; identification of highway project risks; analysis of highway project risks, responses to highway project risks, and monitoring and reviewing of highway project risks. For each of the identified top nine most critical risks for the Nigerian highway project risk, mitigation measures are provided

Chapter 9: Framework Evaluation

9.1 Introduction

This chapter presents the evaluation of the risk management framework for highway construction projects in Nigeria. The evaluation aims to ensure that it meets the needs of construction professionals involved in highway projects in Nigeria.

9.2 Framework Evaluation

In construction project management research, framework evaluation is essential to ensure that it meets the quality standard criteria requirements and that it satisfies its proposed objectives (Lucko and Rojas, 2009). It is a significant component of a scholarly research process and it is useful to attest the validity of the proposed highway risk management framework. According to Mahmoud et al., (2009) a framework requires evaluation if it must have any significant effect on decision making. It is important that the researcher collaborates with the industry practitioners to prove the reliability of the developed risk management framework. The literature review identified two broad areas of the process of evaluation as establishing the internal and external validity (Lucko and Rojas, 2009; Saunders et al., 2015). Additionally, other commonly mentioned validation process in literature include: face validity, content validity, criterion validity and construct validity.

9.3 Evaluation findings

In order to evaluate the Nigerian highway risk management framework presented in Figure 8.1, expert opinions of those involved in four cases of highway construction projects in Nigeria were sought. Semi-structured interviews were conducted with sixteen highways industry practitioners drawn from four cases of on-going highway infrastructure construction project located in different geo-political zones of Nigeria. Each interview was carried out on a one-to-one-basis, following an interview guide, as shown in Appendix 11. The guide is divided into two sections: section 1 (general background information) and section 2 (framework evaluation). Table 9-1 shows the background information of the interviewees. As seen in the table, the interviewees had extensive experience in highway infrastructure construction projects and had been involved in many highway projects. They had high profile designations in the highway construction industry and were members of relevant professional bodies.

Section two of the interview aimed at gaining Nigerian highways practitioners' perceptions and critiques of the framework as a basis for amendment and improvement. It also paved the way for the independent evaluation of the framework with respect to the criteria of clarity, comprehensiveness, practical relevance and suitability of the framework. These criteria were adapted from previous construction project management research frameworks (e.g. Holsapple and Joshi, 2000; Mahmoud et al., 2009; Dey, 2012).

Table 9- 1: Background information of the evaluation interviewees

Interviewee Code	Professional membership	Designations	Organisation type	No. of highway projects involved with in the past 3yrs	Years of experience in highway projects
V1	NIQS & QSRBN	Contract Administrator	Joint Venture	4-6	11
V2	COREN	Chief Engineer	Government	4-6	16
V3	NSE, MNIHTE, COREN (CHF. EXAMINER, SOUTH-SOUTH)	Executive Consulting – Civil, Highway & Transportation	Consultant	7-10	27
V4	NSE, COREN, FIAM, ACPM & PFDNICE	Deputy Director Highways Construction & Rehabilitation	Government	7-10	24
V5	NSE & COREN	Project Manager, Highways Construction & Rehabilitation	Government	4-6	19
V6	NSE & COREN	Engineer, Dualization of Abuja-Lokoja Road	Government	4-6	10
V7	COREN	Project Manager	Local Contractor	4-6	16
V8	NIS& FICGN	MD /CEO	Consultant & Int'l Contractor	4-6	16
V9	COREN	Manager	International contractor	4-6	16
V10	NIQS, QSRBN AND AACE	Project Quantity Surveyor & Cost Engineer	Joint Venture	4-6	10
V11	COREN	Project Consultant	Consultant	7-10	20
V12	NIQS	Quantity Surveyor	International contractors	7-10	11
V13	NSE & COREN	Project Engineer	International contractor	4-6	9
V14	NSE & COREN	Senior Project Development Engineer	International contractor	7-10	16
V15	COREN	MD	Local contractor	4-6	27

V16	NIQS, RQS, AACE	Cost Engineer & PhD researcher	International contractor	22	11

Where: COREN = Council for the Regulations of Registered Engineers in Nigeria; NSE = Nigerian Society of Engineers; NIHTE = Nigerian institution of highways and transportation engineering; NIQS = Nigerian Institute of Quantity Surveyors; QSRBN = Quantity Surveyor Registration Board of Nigeria; NIS = Nigerian Institute of Surveyors; FICGN = Fellow of Institute of Certified Geographers of Nigeria; FIAM = Fellow of International Academy of Management; ACPM = Associate Chartered Project Manager; PFDNICE = Professional Fellowship Doctorate of the Nigeria Institute of Chartered Economists; AACE = American Association of Cost Engineering

Interviewees were also asked for their views regarding the following aspects: specific guidelines/instructions for the application of each of the phases of the framework; usefulness or relevance of the proposed risk register for managing risks in Nigerian highway construction projects; proposed mitigation measures for the top nine most critical risks for Nigerian highway construction project; limitations or weaknesses of the framework; other potential areas of use of the framework and general overview and any suggestions (if any) for improvement of the framework

9.3.1 Clarity and comprehensiveness of the overall framework

Interviewees were requested to comment on the clarity and comprehensiveness of the overall framework. For the framework to be effective it is pertinent to establish its clarity and comprehensiveness. There was a consensus among the interviewees that the overall framework is 'technically comprehensive'. According to V2 '*the framework is clear and very comprehensive especially the manner in which the processes were outlined'*. In addition to confirming the clarity and comprehensiveness of the framework, interviewee V5 (Project Manager, Highways Construction & Rehabilitation) emphasized that the section that made provision for more detailed information, which makes it particularly interesting and easy to use. According to interviewee V7, another project manager, '*the framework is clear and very comprehensive as it details logical step-by-step processes of risk management in highway construction projects'*. Interviewee V9 commented that '*The framework is well structured and covered the key risk management processes with clear and detailed guidelines'*. Interviewees V11 and V12 further stated that the framework is free from ambiguity and that there was no omission of important details. Interviewees V13, 14 & V15 further commented that the framework and the mitigation measures are very clear, comprehensive and very explanatory. Following the opinions of the Nigerian highway professional on these assessment criteria, the technical clarity and comprehensiveness of the proposed Nigerian highway risk management can be ascertained

9.3.2 Practical relevance and suitability of the framework

Interviewees were requested to comment on the practical relevance and suitability of the framework to the Nigerian highway construction project risk management. In response to this interview, all the interviewees confirmed the practical relevance and suitability of the framework to the Nigerian highway construction projects. V2, a chief engineer and government representative stated that '*the highway construction process in Nigeria does not undertake rigorous risk assessment, management and mitigation as expected. This framework when fully followed and implemented will enhance risk management'*. This suggests that risk management is currently on an 'ad hoc' basis. From the viewpoints of V3 (Executing consulting - civil highway & transportation; chief examiner from South-South region) & V4 (Deputy Director, highways construction & rehabilitation): '*the framework is very constructive and adaptive; best practice and best fit approach for the Nigerian road sector'*. According to V5, a project manager, '*the framework is particularly relevant in Nigerian highway construction industries. Considering the economic situation in Nigeria and unavailability of fund for capital intensive project, this framework is cost effective and with training for the project delivery teams, this framework is suitable for developing nations not only on road projects but other areas of infrastructure like hospital, school buildings and low to medium size construction projects'*. V10 shared a similar view by saying: '*the Framework is just in time to meet the global standard. Interestingly, the recommendation does not require sophisticated techniques which are costly to perform. This makes it cost effective; hence it is a useful tool for the management of risk in Nigeria if Nigeria government and industry professional will integrate risk management culture into the system'*. To buttress these views, V7 asserted that '*the framework was thorough and cost effective and would suit the Nigerian economic and political environment as well as other developing countries that shared common distinctive features with Nigeria'*. V9, V14 and V15 added that the framework and the mitigation measures are useful steps toward the improvement of highway project risk management in Nigeria and to ensure successful delivery of highway projects, as it will address and include all stakeholders; they added it could be practically possible. V16, a cost engineer and a researcher had a somewhat different but detailed and well-informed view that '*In terms of practicality, it takes a very organized project team to drive this through, considering the under-regulated project environment such as Nigeria'*. It will certainly take a well-organised project management team to implement any risk management framework, no matter how good the comprehensiveness and clarity of the framework. Considering the interviewees'

comments, it can be said that the proposed risk management framework is practically relevant and considered to be suitable for the Nigerian highway construction infrastructure project and for other developing countries.

9.3.3 Specific guidelines/instructions for the application of each of the phases of the framework

Interviewees were requested to express their views on each of the specific guidelines/instructions for the application of each of the phases of the framework. The findings of the interviews revealed that specific guidelines/instructions for the application of each of the phases of the framework are: quite comprehensive, self-explanatory, concise and adequate for realistic risk management processes. Other useful information was contributed by V10, '*Like I have stated earlier at the commencement of my review, every guide line listed are just in time. Nigeria as a Nation is long overdue for the implementation of a global standard frame. But Bad Governance, corruption and lack of competency of people in positions of authority have done so much damage to all facet of the economy'*. From the view point of V11 the guidelines were: *'Quite logical in nature and represent an all-purpose mechanism for managing project risks in construction industry'*. V13 added that, '*They are very good and useful especially the logical sequence of the guidelines'*. V16 recommended that '*there should be practicable enforcement rules to support the guidelines; otherwise there will be evasion of instructions'*. This recommendation is outside the control of the researcher. If the framework has satisfied the entire fundamental requirement it is up the responsible government to adopt a system to implement it. In view of the interviewees' comments, it can be said that overall there are valuable, clear and detailed guidelines/instruction for the application of each of the phases of the framework.

9.3.4 Usefulness or relevant of the proposed risk register

To evaluate other components of the framework, interviewees were further requested to express their views regarding the usefulness or relevance of the proposed risk register for managing risks in Nigerian highway construction projects. In response to this question, the interviewees described the proposed risk register as very comprehensive and extremely relevant. In support of this, V1 asserted that '*the proposed risk register is very useful and recommended for implementation. (Incidentally, the call for a guide like this for managing risks in Nigerian highway projects has come up in professional*

symposia in the country (Nigeria)'. From the viewpoint of V5, '*The risk register is a useful guide for keeping track of highway construction project risks and any other construction project risks*'. V8 added that, '*It is very useful especially keeping track with the post mitigation analyses*'. V6 stated that '*the risk register Template gives the overall details of the risk at a glance, which includes the risk identification, risk analysis, risk response and post mitigation analysis. This makes it very useful and relevant register for managing risk in Nigerian highway construction projects'*. V7 expressed it in this way: '*I find it very clear and easy to understand. This will be a useful tool to keep record of highway risk management processes. It is comprehensive as it covers all the risk management stages even up to the extent of post mitigation strategies'*. V9 stated that it will add value to the project risk management process if implemented. He considered that it covered all the risk management processes and this will help project participants to keep track of risk at all phases of the risk management stages and even the project phases. However, he believed it will be very useful, if and only if the right policy makers will implement it when proposed to them for implementation. V10 shared a similar view; saying that, '*It will be very useful, if and only if the right policy makers will implement when proposed to them for implementation'*. According to V13, '*I consider it to be very useful as it details the overall risk management processes such risk identification, analysis and mitigation processes as well as the people involved. This will help for accountability for risk reporting'*. Judging from the views of the interviewees, it can be concluded that the risk register component of the framework is established to be very comprehensive and extremely relevant for keeping track of highway construction project risks and any other construction project risks and will add value to project risk management processes.

9.3.5 The proposed mitigation measures for the top nine most critical risks

To further evaluate the framework in details the interviewees were asked, 'are there any of the proposed mitigation measures (**Appendix 9**) for the top nine most critical risks for Nigerian highway construction project you think is/are not relevant that should be removed? Please comment.' The interviewees confirmed that all the proposed mitigation measures are relevant as they address the most prevalent risks facing Nigerian highway construction projects; hence, none should be removed. Nevertheless, V8 expressed a concern that the mitigation measure M27, funding projects from sources not affected by interest rate hikes seems impracticable in Nigeria. Additionally, V16

pointed out, '*They are all relevant, but I doubt the possibility to get insurance for political risk. How do you measure that?*'

9.3.6 Limitations or weaknesses of the framework

Interviewees were requested to comment if there are any limitations or weaknesses of the framework. In summary, the interviewees were fairly positive about the framework. However, most of them believed that the success of its application depends on:

- A well-organized project team to drive this through, considering the under regulated project environment such as Nigeria and involvement of project stakeholders such as the local community within which the project is situated.
- Nigeria's peculiar situation, such as the prevalence of bad governance, corruption and lack of competency of people in positions of authority
- The willingness of the Nigerian government and industry practitioners to integrate the risk management framework into the system.

Furthermore, there were some critiques about the application of some of the proposed mitigation measures provided for the top 9 critical risks within the Nigerian context. The evaluation suggested that that the proposed mitigation measure M27, funding projects from sources not affected by interest rate hikes, seems impracticable in Nigeria as well as mitigation measures: M16, M49 and M52 'getting insurance for political risks'.

The evaluation feedback also reveals that the participants recommended there should be practicable enforcement rules to support the guidelines; 'otherwise there will be evasion of instructions'. Referring to the overall risk management framework presented in Figure 8.1, one of the interviewees suggested that the orange arrow should feedback into the risk management plan to make it cyclical (see section 9.2.8 for further discussion).

9.3.7 Potential areas of usage of the framework

The framework was specifically designed for Nigerian highway construction project risk management. To assess its extensive areas of application, the interviewees were requested to identify other potential areas where they thought the framework could be used. The interview findings reveal that they believed the framework has a comprehensive coverage and as such could be used on all infrastructure projects across

developing countries that shared some political, economic and other characteristics with Nigeria. According to V4, *'the framework has a comprehensive coverage and could be used on all infrastructure projects, namely buildings, airport, railway, dams etc., in Nigeria. In the same domain it can also be used in other developing countries that shared some similarities with Nigeria'*. V5 further emphasized that this framework is suitable for developing nations not only on road projects but other areas of infrastructure like 'hospitals, school buildings and low to medium size construction projects'. According to V10: '*I think all aspect of Infrastructural development of the economy should see this as veritable tool. I.e. all aspect Constructions, be it highway, Building, Civil and other heavy engineering works'*. V16 stated that the framework is suitable for private projects, NGO-funded projects, and projects funded by international agencies.

9.3.8 General overview and suggestions (if any) for improvement of the framework

Interviewees were required to provide their general overview and any suggestions for the improvement of the framework. The interview findings of their general overview of the framework are that it is a comprehensive, excellent, well-researched and very satisfactory framework that suits developing countries. V1 stated, '*Job well done'*! V3 asserted that, '*This is an excellent framework as it covers the entire risk management element from planning to monitoring and reviews'*. According to V5, '*This is a thorough framework that satisfies the requirements of construction projects. It covers all the risk management elements with clear guidelines of what to do. I will recommend this framework to be used on both public and private infrastructure projects in Nigeria and countries that have some similarities with Nigeria'*. V6 added that, '*the framework will be of significant importance for highway construction projects in Nigeria as it will help in mitigating risks on highway construction sites'*. V8 commented that '*this is a well-researched work. I only hope risk management is taken seriously and risk experts engaged for all construction processes, similarly this work should be made to get to the Nigerian authorities in the construction industries when concluded*,' In the opinion of V10, '*I believe this is good tool for now. While the current Government fight against corruption and other vices, will definitely welcome this. Most especially with the desire of the present Government to re-building of the North East region of the Country infrastructures destroyed the insurgencies*.' V14 further added that '*The framework provides a disciplined and structured process in the life cycle of highway projects that*

will ensure its successful delivery,' while V16 ended with a complimentary note: '*Very satisfactory framework that suits developing countries.*'

V4 commented that *the framework is clear and captures all the requirements for comprehensive risk assessment and that the guidelines are quite comprehensive as well but would like to recommend that other stakeholders, like the local community within the project corridor, must be involved from the onset and ''through and through''*. He emphasized that the cultural peculiarity, religious diversity and other variances in Nigeria that sometimes puncture most of the globally acclaimed best fit approaches to projects and, in particular, risk management on projects. He further explained that sometimes project fail from day one, because there is no community ownership, so they do all it takes to frustrate the project despite its obvious benefits to them. According to V16: '*The framework was clear and the explanatory notes made it easier to understand each stage of the framework. However, I believe it should be cyclical; the orange arrow should feedback to the first box (roles, objectives, processes and procedures changes with project'*. That stage simply defines the process to be followed and requires no major changes, as explained in section 3.1.1.

9.3.9 Any existing risk management framework for highway construction projects in Nigeria?

The final interview question asked the interviewees: Are you aware of any existing risk management framework for highway construction projects in Nigeria? If yes, please provide more details to include any difference between the existing risk management framework in Nigeria and the one I have developed. The answers to this interview were as follows: *These are often embedded in the contents of the various consultant services either on the sponsor's side or the executor's side. The details are therefore not easy to access.* (V1); *Not to the best of my knowledge* (V2); *Not sure of any comprehensive risk management framework for addressing risks in Nigerian highway projects* (V3); *none as far as I know (V4); I am not aware of any formal risk management framework that is in practice in Nigerian highway construction projects* (V5); *Not sure if there is any (V6); No (V7); The usual practise is risk transfer in terms of insurance and performance bond* (V8); *For now, none* (V9); *None* (V10); *Can't think of any* (V11); *No* (V12); *My company manages risks as they arises but no comprehensive framework as what you have developed* (V13); *None* (V14); *None to the best of my knowledge* (V15); *None as far as I know* (V16).

From the interviewees' comments above it is obvious that currently, there exist no risk management frameworks for the Nigerian highway infrastructure construction projects.

Judging from the interviewees' comments on all the components of the developed framework, it can be said that the proposed framework is a valid approach for managing risks associated with highway infrastructure construction projects in developing countries, particularly Nigeria, that could potentially improve the performance of the projects. However, before it could be successfully implemented in practice, it will take a very organized project team to drive this through, considering the under-regulated project environment in Nigeria and, secondly, the local community within the project corridor must be involved from the onset and ''through and through' considering the cultural peculiarity, religious diversity and other differences in Nigeria.

9.10 Chapter summary

To evaluate the framework, semi-structured interviews were conducted with sixteen highways industry practitioners drawn from four cases of on-going highway infrastructure construction project located in different geo-political zones of Nigeria.

The results indicated that for this framework to be implemented it will need a well-organised project delivery team and it has to be driven by the local community within the project corridor. More importantly for the effective implementation of this framework, the public client (the Nigerian government), the contractors and consultants need to be educated about the potential time and cost savings that will be gained through implementing the framework.

It is considered that this chapter has filled the knowledge gap area in the Nigerian highway construction industry regarding the lack of a comprehensive risk management framework for improving the management of risks. It has established that the proposed mitigation measures for the key risks are suitable to guide the Nigerian highway practitioners in managing risk associated with their projects.

Chapter 10: Summary of Research Findings, Conclusions and Recommendations

10.1 Introduction

The main focus of this research is to develop a risk management framework aims at improving the management of key risks in Nigerian highway infrastructure construction projects. This chapter presents the overall summary of the research findings in relation to the research objectives outlined at the beginning. In this Chapter conclusions are drawn followed by a discussion of the limitations of the research and recommendations for future research.

10.2 Research findings and fulfilment of research objectives

The achievements of research objectives are summarised below:

- **To gain the state-of-the-art knowledge in risk management involving civil engineering infrastructure construction projects**

Various risk factors are associated with large public infrastructure projects such as highway infrastructure construction projects) and the performance of such projects depends on the efficient and effective management of the critical risk factors. Hence, comprehensive risk assessment is fundamental to understanding and improving the risks of major infrastructure projects (Wang et al., 2016). Ensuring effective delivery of highway construction projects to cost, schedule, and performance requirements and the need for environmental sustainability requires identifying and managing the associated risks. Beginning from the feasibility phase to the operational phase, the risk involved in major infrastructure projects can have direct effect on the project schedule, cost and overall performance. Unfortunately, as the literature reviews on risk management have shown, the project management methodologies that have been adopted in developing countries do not readily make provisions for the increasing demands for risk management (Chouldhry and Iqbal, 2013). This is particularly true in Sub-Saharan African, including Nigeria. Hence, as emphasized by Chileshe and John (2014), there is a growing need for specific research regarding risk assessment and management practices, especially within sub-Saharan Africa. One of the major reasons for the poor performances of highway construction projects in developing countries can be attributed to lack of understanding of and effective application of risk management (Choudhry & Iqbal, 2012; El-Sayegh & Mansour, 2015; Reza et al., 2016).

Extensive reviews further identified the following gaps:

- Although there have been considerable efforts in large infrastructure project risk management research, there is still a lack of specific investigation that can increase the understanding of risk management in highway construction infrastructure projects in developing countries
- Data on highway projects and experts' feedback in developing countries are small in quantity and limited.
- Hence, little evidence and information exists for the application of risk management in construction projects from the perspective of developing countries.
- Therefore, a there is an essential demand for a more efficient and effective approach to improve the management of highway projects in developing countries.

To further gain the state-of-the-art knowledge required, a comprehensive review of risk management processes (framework) has been undertaken and the findings reveals that:

- The risk management process offers a consistent framework for identifying and understanding possible risk factors, assessing consequences and their uncertainties, and evaluating and choosing the best courses of action necessary to handle the identified risks in order to accomplish the desired project objectives.
- There is limited knowledge, understanding and practice of risk management processes and techniques in the context of highway construction project in developing countries.
- There is gap in research considering the collective involvement of key project participants (client, consultant, and contractor) to identify, analyse and respond to risk associated with highway construction projects in Nigeria to establish a ranking of risks facing the construction industry
- There is a gap in research to identify and analyse the important risks associated with highway infrastructure construction projects in Nigeria
- There is no research that has investigated the risk management processes and techniques currently used in highway construction projects in Nigeria and evaluate their effectiveness

In view of these issues, this research is undertaken mainly to bridge this gap of the knowledge area in Nigeria. The specific objectives outlined to satisfy this core aim result from the gaps identified from literature review findings.

- **To identify and analyse the important risks associated with highway infrastructure construction projects in Nigeria**

35 risk factors were identified from literature, as shown in Table 3-3 for highway infrastructure construction projects in Nigeria. A questionnaire survey with highway project practitioners has established the particular relevance of these risks in Nigeria. Analysis of the survey results identified three categories of risks associated with highway infrastructure construction projects in Nigeria: highly possible risk (more critical); low risks (less critical); and very low risks (rarely critical). No risk was found to be very high risk (most critical); nor were possible (Somewhat critical) or unidentified risks. The top nine risks that were found to be more critical, as shown in Table 5-15, are, in order of priority: project funding challenge (internal); construction time delay (internal); political interference (external); exchange rate fluctuation (external); inflation/interest rate fluctuation (external); construction cost overrun (internal); government officials demand bribe /unjust reward (external); unstable government (external) and project being cancelled due to change in ruling party (external). The case study interview findings about the risks associated with highway infrastructure construction projects in Nigeria were consistent with the questionnaire findings. These findings suggest that external risks have significant consequence on the performances of highway infrastructure construction projects in Nigeria; whereas internal risk has little consequence on the performance of highway construction projects in Nigeria. This finding is inconsistent with those of El-Sayegh and Mansour (2015) in the United Arab Emirates (UAE), who found that external risks had only a minor effect on the UAE highway construction industries. This inconsistency arises as a result of their differences in political, cultural and socio economic environments. Whereas the UAE is a relatively authoritarian society, Nigeria is democracy. The result of the factor analysis suggested that the 35 risk sub-factors associated with highway construction projects in Nigeria could be grouped into ten distinct risk groups as shown in Table 6-6.

- **To investigate the risk management processes and techniques currently used in highway construction projects in Nigeria and evaluate their effectiveness**

Respondents were presented with: six risk identification techniques; four risk analysis techniques and six risk response techniques identified from the literature and asked to rate the extent of their usage to identify, analyse and respond to potential risks associated with highway infrastructure construction projects in Nigeria as well as their corresponding effectiveness (see details in section 6.4) in a questionnaire-based survey. The analysis revealed that the overall ranking of risk identification techniques currently used to identify risks associated with highway construction projects in Nigeria is reasonable, with the top three often used being consulting experts, brainstorming and checklists. They were found by the participants to be moderately effective. The case study interview findings about the risk identification techniques and their effectiveness with highway infrastructure construction projects in Nigeria were consistent with the questionnaire findings. The overall evaluation of risk analysis techniques currently used in the Nigerian highway construction projects was found to be equally reasonable, with the top two being consulting experts and qualitative analysis techniques. These were also found to be moderately effective. On the risk response techniques, the overall evaluation shows that the Nigerian highway experts tended to reduce the possibility of occurrence of the risk followed by reducing the consequences of occurrences and avoiding the risks. These were also found to be moderately effective, as revealed by the opinion of all the participants. The findings of a follow up case study interview were also consistent with these findings. The risk management methodologies adopted in the Nigerian highway construction project seem to be informal, which is not sufficient for managing highway project risks

- **To develop a new risk management framework to improve the management of the identified and analysed key risks**

Following the identification of the top nine critical risks that affect the performance of highway construction projects in Nigeria a new risk management framework was developed, as shown in Figure 8-1, to improve the management of these risks.

The framework development was based on the principles outlined in Section 8.2 (e.g., building on existing risk management frameworks; making use of existing risk management tools that are successfully used in other countries; providing practical guides for professional working on highway projects in Nigeria. The framework consists of five distinct phases and the guidelines for the application of each of the phases were provided. For each of the top nine critical risk factors identified, practical mitigation measures are provided (Appendix 9).

- **To evaluate the newly developed risk management framework**

Semi-structured interviews were conducted with sixteen highways industry practitioners drawn from the four cases of on-going highway infrastructure construction projects located in different geo-political zones of Nigeria to evaluate the framework. The practical mitigation for each of the top nine critical risk factors was also evaluated by interviewing 16 highway experts drawn from each of the selected large scale highway projects. The evaluation process and the findings were presented in the preceding chapter. The overall feedback revealed that the interviewees were fairly optimistic about the framework. They were in support of adopting the framework for their highway projects' risk management. The evaluation findings showed that the proposed risk management framework was considered to be very clear and comprehensive; practically relevant and considered to be suitable for the Nigerian highway construction projects and those in other developing countries. They also agreed that it has valuable, clear and detailed guidelines for its application, the risk register component of the framework is very comprehensive and extremely relevant for keeping track of highway construction project risks and that almost all the mitigation measures for each of the top nine critical risk are all relevant, as they address the most prevalent risks facing Nigerian highway construction projects; hence, the participants felt that none should be removed. Therefore, it can be said that the proposed risk management framework for the Nigerian highway construction projects is a valid approach for managing risks associated with highway infrastructure construction projects in developing countries, particularly Nigeria, that could potentially improve the performance of the projects.

Nevertheless, they were in consensus that the success of its application depends primarily on:

- Well-organized project teams, considering the under regulated project environment in countries such as Nigeria, and involvement of project stakeholders such as the local community within which the project is situated.
- Nigeria's distinctive situation, involving bad governance, corruption and lack of competence of people in positions of authority
- The willingness of the Nigerian government and industry practitioner to integrate the risk management framework into the system'

Additionally, the interviewees were concerned about the practicability of funding projects from sources not affected by interest rate hikes in Nigeria (M27) and getting

insurance for political risks for the proposed mitigation measures. These reflect the view that these measures could be practicable and effective in other countries but not in Nigeria. It also reveals the ineffectiveness of insurance as a measure for managing political risks in Nigeria.

It is recommended that mitigation measures should be prioritised for risks with higher criticality index (El-Sayegh and Mansour, 2015; Wang et al., 2004). For effective implementation of this framework it is recommended that: the project delivery team needs to be well organised and it has to be driven by the local community within the project corridor; the public client (the Nigerian government), the contractors and consultants need to be educated about potential time and cost savings that will be gained through implementing the framework. Additionally, it is recommended that the Nigerian government should provide the project delivery team with proper planning, coordination, and approval for effective risk management implementation.

10.3 Contribution to knowledge

Risk management is relatively new in the Nigerian construction industry. Hence, it has been under researched and under-represented the current body of knowledge, internationally. This research contributes to filling this knowledge gap and can help to improve the risk management practice in highway projects in Nigeria through the delivery of the following outputs:

- The major contribution of the framework is in providing guidelines for the Nigerian highway experts as explained in section 8.5
- Development of a risk management framework for highway construction projects in Nigeria
- Development of the mitigation measures for the top critical risks for the Nigerian highway construction projects
- Identification and classification of the critical risk factors affecting the performance of highway construction projects in Nigeria
- Development of a risk register template for the management of these risks
- Provision of techniques and tools for highway project risk management and provision of guidance on how to pre-emptively respond to highway construction project risks.

The developed risk management framework offers the following benefits:

- The overall research findings would guide the management to direct efforts toward key risk factors and develop suitable mitigation strategies to comprehensively manage major infrastructures projects.
- Provide a reliable approach to undertaking project risk management tasks. Provides techniques and tools for highway project risk management and provide guidance on how to pre-emptively respond to risks.
- The framework could additionally act as a foundation stone for the Nigerian government to build up to improve the management of risks associated with highway construction projects in Nigeria.
- The evaluation feedback has shown that the framework is relevant to practitioners by providing them with tools to plan, identify, analyse, monitor and review; and then prioritised the risks associated with highway construction infrastructure projects in developing countries and hence boosts the possibility of a successful project performance in a unique environment with cultural specificity, religious diversity and other variables.
- It can also benefit future researchers by providing them risk groups and subgroups, methods of evaluating these risks and a methodology for assessing the effects of these risks.
- The overall research will benefit both the local and foreign companies that wish to tender for highway construction projects in Nigeria, and help them to be extremely careful about the political, corruption, economic and financial risks.

  In view of the above points, it can be said that the research has contributed to the body of knowledge in the area of highway project risk management from developing country perspective, particularly Nigeria

Special attention should be given to risk management in the Nigerian highway construction projects. Risk management planning, identification, analysis, response, monitoring and reviewing should be systematically conducted for highway construction projects in Nigeria

For each of the identified risks, practical mitigation measures were provided and evaluated.

It is suggested that when mitigating a specific risk, the mitigation measures should also be prioritized by the higher risk criticalities. It is recommended that further quantitative risk analysis should be performed for the key risk identified. The identified risk may be generalised since they emerged through literature review from different countries.

Notwithstanding, the criticality of those identified are specific to the Nigerian case. For the analysis of risk of similar highway projects, the identified risk list and criticality can be partly used for reference. For a more complex highway projects comprehensiveness of the analysis should be given further attention.

Project delivery can be improved by setting up and keeping a risk register over the lifecycle of a project. The risk register ensures that project risks, analysis and responses are communicated through the project phases, so that risks are known, understood and effectively managed. Hence, a risk register templated provided could be a useful tool for identifying; analysing and categorising the risks associated with highway infrastructure construction projects in Nigeria and provide the means of developing a cost-effective method of managing them.

10.4 Limitations of the research

Due to time and resource constraints, this study has a number of limitations:

- The research has a specific and limited scope. It focused on risk management in highway projects during the construction phase in Nigeria. Although some findings may be applicable in other countries, comparative studies need to be conducted in order to ascertain this. Risk and risk management are relevant to all phases of highway projects, the consequences of risks during construction phase are usually more tangible, and hence this study chose to focus only on this phase.
- The research experienced difficulty during data collection right from the onset. When it was time to travel to Nigeria for data collection, the university authority advised against travelling to Nigeria, as the terror threat was high. This led to the data being collected remotely with the help of recruited research assistants in various geo-political zones of Nigeria. Some top government officials declined to participate in data collection for the reason that the questions were too specific and that the contracts were still on going and they did not wish to provide the researcher with the project management details. Efforts made to boost the response rate have been already discussed in section 4.8.4.

- The developed risk management framework represents a specific application of existing risk management principles in the new domain of highway projects in

Nigeria. The contribution of this study is not on the theoretical aspects of risk management, but rather is on its practical application.

- The evaluation of the framework relied on expert reviews. There was no opportunity to implement the framework in a real world project, in order to evaluate its application.
- During the expert evaluation, it was found that the successful application of such a risk management framework depends on many factors other than the framework itself, such as clear demands from the client, the competence of the project team, buy-in by all stakeholders, and so on. These broader issues were beyond the scope of this study.

10.5 Recommendations for future research

Following the limitations of the research the following recommendations are made for the improvement of knowledge in this subject area:

- The risk management framework development was specifically for highway construction infrastructure projects in Nigeria. It is recommended that further parallel studies should be conducted to identify and analyse the important risks associated with highway infrastructure construction projects and to investigate the risk management processes and techniques currently used in highway construction projects and evaluate their effectiveness in other countries and make cross-country comparisons.
- Further studies using the same approaches should be conducted on private construction projects in Nigeria to see if any differences or similarities exist.
- Further research should be performed on other economic infrastructure projects (e.g. power generation and supply, water supply, telecommunications, railway and airport) or with social infrastructures like schools, hospital to investigate any inconsistencies.
- Although risk was defined to include both the positive (opportunity) and the negative (threat), in this research only the negative aspect of risk was investigated. Further research should be undertaken to investigate both the positive and negative aspects of risk while studying risk management in the Nigerian highway infrastructure construction projects.
- Concurrent mixed methods research were adopted in the current research, in which quantitative and qualitative methods were used independently in a single

phase of data collection and analysis. For future research it is recommended that a sequential mixed method should be adopted. This process involves the researcher following the use of one method with another, so as to expand on the initial set of findings. This could be either sequential exploratory research design (qualitative followed by quantitative) or sequential explanatory research design (quantitative followed by qualitative).

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Appendix

Appendix 1: Questionnaire Survey

Dear Sir/Madam**,**

Invitation to Doctoral Research Survey: Risk management framework for highway construction infrastructure projects in Nigeria

I am delighted to invite you to take part in a postgraduate research survey. The research aims to develop a new risk management framework to improve the management of highway construction infrastructure projects in Nigeria.

The questionnaires aim to identify the most important risks affecting the performance of highway construction infrastructure projects in Nigeria. They will further assist to investigate risk management processes and techniques currently used in highway construction projects in Nigeria.

The information provided will be vital to this research work, especially to develop a new risk management framework to improve the management of highway construction infrastructure projects in Nigeria. Be assured that your responses will be anonymous and confidential following the University's Research Code of Practice. In appreciating your kind help, I will be happy to send you an executive summary of the report when the study is completed if you wish to have one. Please feel free to contact me should you have any query or simply want to discuss more about the study. I would like to receive completed questionnaires on or before 15 June 2015. The survey can be completed at any time up until this date.

To participate in the survey please click here. Once the link is opened, click next to continue and submit when you have finished.

Thank you for your time and contribution to my research.

Yours Faithfully,

AKOH, Sani Reuben

Doctoral Research Student

Supervisors:

Professor Ming Sun

Professor Stephen Ogunlana

Section 1: General Background Information

1.1 Name of respondents (Optional)----------

1.2 Telephone Contact----------

1.3 E-mail address----------

1.4 Please state your current job tile/position----------

1.5 Please select from the options below your years of working experience in the highway construction industry.

≤ 1	1 - 5	6 - 10	11 - 15	16 - 20	≥ 20	Other (Specify)
☐	☐	☐	☐	☐	☐	☐

1.6 Please tick one box only below to indicate the type of organisation you are working for

Government	International Contractor	Local Contractor	Consultant	Joint Venture	Other (Specify)
☐	☐	☐	☐	☐	☐

1.7 Please tick one box only to indicate your profession from the following:

Engineer	Quantity	Architect	Project mgr.	Site Mgr.	Other (specify)
☐	☐	☐	☐	☐	☐

1.8 Please select one from the options below that best indicates the number of highway projects you have been involved in over the past three years)

None	1 - 3	4 - 6	7 - 10	Other (specify)
☐	☐	☐	☐	☐

1.9 Please tick one box only from the following to indicate the value (Billion Naira) of the highway project portfolio that you currently managed:

≤ 1	2 - 5	6 - 10	11 - 15	16 - 20	21 - 25	Other (Specify)
☐	☐	☐	☐	☐	☐	☐

1.10 Please tick only one box below that best describes the management of highway construction infrastructure projects in Nigeria

Very poor	Poor	Fair	Good	Very good
☐	☐	☐	☐	☐

1.11 Please tick to select only one option in each case below that best states how the following procurement methods are used in the delivery of highway construction projects in Nigeria as shown

Procurement methods	Usage of procurement methods in Nigeria Highway projects				
	Never	Sometime	Often	Usually	Always
Traditional methods	☐	☐	☐	☐	☐
Design and Build	☐	☐	☐	☐	☐
Management contracting	☐	☐	☐	☐	☐
Construction Management	☐	☐	☐	☐	☐
Public Private Partnerships	☐	☐	☐	☐	☐
Others	☐	☐	☐	☐	☐

1.12 Please select only one option from the options below that best rates your knowledge of risk management in highway construction infrastructure projects

Very poor	Poor	Fair	Good	Very good
☐	☐	☐	☐	☐

1.13 Please tick only one box from the options below to indicate how you would rate the performance of highway construction infrastructure projects in Nigeria based on following factors: completion time, cost, quality, environmental sustainability and stakeholder management

Performance of highway Construction projects in Nigeria	Very poor	Poor	Fair	Good	Very good
Timely completion	☐	☐	☐	☐	☐
Within budget (to cost)	☐	☐	☐	☐	☐
Quality	☐	☐	☐	☐	☐
Environmental sustainability	☐	☐	☐	☐	☐
Stakeholder management	☐	☐	☐	☐	☐

1.14 Please tick only one box to express your opinion for each of the following statements

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
There is no formal requirement for the management of risks in Nigerian highway construction industries	☐	☐	☐	☐	☐
Nigerian highway construction practitioners urgently need risk management knowledge and expertise in managing highway construction projects risks	☐	☐	☐	☐	☐
Managers' proficiency in risk management play a crucial role in project risk management	☐	☐	☐	☐	☐
Risk management will attract substantial extra cost of management expenses and time	☐	☐	☐	☐	☐
Project risk management in Nigerian highway construction projects is often dealt with inadequately	☐	☐	☐	☐	☐
I am satisfied with the way highway construction infrastructure projects are being managed in Nigeria	☐	☐	☐	☐	☐

Section 2: **Identification & Analysis of Risk factors affecting the Performance of Highway Construction Infrastructure Projects in Nigeria**

This section identifies major risk factors affecting the performance of highway construction infrastructure projects in Nigeria

2.1 Please tick only one box in each case to indicate the possibility of occurrence of the following risk factors on the performance of this highway infrastructure projects in Nigeria, as shown:

Risk factors that may affect performance of highway projects in Nigeria	**Possibility of occurrence**				
	Very Low	Low	Medium	High	Very High
Unstable government	☐	☐	☐	☐	☐
Project being cancelled due to change in ruling party	☐	☐	☐	☐	☐
Strong political interference	☐	☐	☐	☐	☐
Expropriation /Nationalization	☐	☐	☐	☐	☐
Government officials demand bribe /unjust reward	☐	☐	☐	☐	☐
Exchange rate fluctuation	☐	☐	☐	☐	☐
Inflation/interest rate fluctuation	☐	☐	☐	☐	☐
Level of public opposition to projects	☐	☐	☐	☐	☐
Poor relationship with community	☐	☐	☐	☐	☐
Landowner unwilling to sell	☐	☐	☐	☐	☐
Land acquisition and compensation problems	☐	☐	☐	☐	☐
Inclement weather	☐	☐	☐	☐	☐
Adverse ground conditions	☐	☐	☐	☐	☐
Terrorism attack	☐	☐	☐	☐	☐
Flood	☐	☐	☐	☐	☐
Lack of legal regulatory framework	☐	☐	☐	☐	☐
Weak regulatory & monitoring regime	☐	☐	☐	☐	☐
Unavailability of special equipment	☐	☐	☐	☐	☐
Failure of major constr. equipment & Unavailability of spare parts	☐	☐	☐	☐	☐
Project funding challenge	☐	☐	☐	☐	☐
Construction time delay	☐	☐	☐	☐	☐
Construction cost overrun	☐	☐	☐	☐	☐
Defective design, error and rework	☐	☐	☐	☐	☐
Delay in the availability of design details	☐	☐	☐	☐	☐
Inappropriate procurement methods	☐	☐	☐	☐	☐
High maintenance cost	☐	☐	☐	☐	☐
Poor communication within different parties	☐	☐	☐	☐	☐
Lack of quality control and monitoring	☐	☐	☐	☐	☐
Subcontractors' incompetence	☐	☐	☐	☐	☐
Poor competence of labourers	☐	☐	☐	☐	☐
Shortage of experts in highways	☐	☐	☐	☐	☐
Shortage of skilled labourers	☐	☐	☐	☐	☐
Shortage/unavailability of materials	☐	☐	☐	☐	☐
Lack of commitment between parties	☐	☐	☐	☐	☐
Lack of joint risk mechanism by parties	☐	☐	☐	☐	☐

2.2 Please tick only one box in each case indicate the consequences of the occurrence of the above risk factors on the performance of this highway infrastructure projects in Nigeria, as shown

Risk factors that may affect performance of highway projects in Nigeria	**Consequences of occurrence**				
	Very Low	Low	Medium	High	Very High
Unstable government	☐	☐	☐	☐	☐
Project being cancelled due to change in ruling party	☐	☐	☐	☐	☐
Strong political interference	☐	☐	☐	☐	☐
Expropriation /Nationalization	☐	☐	☐	☐	☐
Government officials demand bribe /unjust reward	☐	☐	☐	☐	☐
Exchange rate fluctuation	☐	☐	☐	☐	☐
Inflation/interest rate fluctuation	☐	☐	☐	☐	☐
Level of public opposition to projects	☐	☐	☐	☐	☐
Poor relationship with community	☐	☐	☐	☐	☐
Landowner unwilling to sell	☐	☐	☐	☐	☐
Land acquisition and compensation problems	☐	☐	☐	☐	☐
Inclement weather	☐	☐	☐	☐	☐
Adverse ground conditions	☐	☐	☐	☐	☐
Terrorism attack	☐	☐	☐	☐	☐
Flood	☐	☐	☐	☐	☐
Lack of legal regulatory framework	☐	☐	☐	☐	☐
Weak regulatory & monitoring regime	☐	☐	☐	☐	☐
Unavailability of special equipment	☐	☐	☐	☐	☐
Failure of major constr. equipment & Unavailability of spare parts	☐	☐	☐	☐	☐
Project funding challenge	☐	☐	☐	☐	☐
Construction time delay	☐	☐	☐	☐	☐
Construction cost overrun	☐	☐	☐	☐	☐
Defective design, error and rework	☐	☐	☐	☐	☐
Delay in the availability of design details	☐	☐	☐	☐	☐
Inappropriate procurement methods	☐	☐	☐	☐	☐
High maintenance cost	☐	☐	☐	☐	☐
Poor communication within different parties	☐	☐	☐	☐	☐
Lack of quality control and monitoring	☐	☐	☐	☐	☐
Subcontractors' incompetence	☐	☐	☐	☐	☐
Poor competence of labourers	☐	☐	☐	☐	☐
Shortage of experts in highways	☐	☐	☐	☐	☐
Shortage of skilled labourers	☐	☐	☐	☐	☐
Shortage/unavailability of materials	☐	☐	☐	☐	☐
Lack of commitment between parties	☐	☐	☐	☐	☐
Lack of joint risk mechanism by parties	☐	☐	☐	☐	☐

Section 3: Investigation of Risk Management Processes and Techniques currently used in Highway Construction Infrastructure Projects in Nigeria and their Effectiveness

3.1 Please tick only one box to indicate the extent of the use of the following risk identification techniques in your organisation to identify potential risks associated with highway construction infrastructure projects in Nigeria.

Risk identification Techniques	**Usage of risk Identification techniques in this project**			
	Never used	Seldom used	Often used	Always used
Historical Data	☐	☐	☐	☐
Checklists	☐	☐	☐	☐
Brainstorming	☐	☐	☐	☐
Intuition/judgement	☐	☐	☐	☐
Interview	☐	☐	☐	☐
Consulting expert	☐	☐	☐	☐
Others	☐	☐	☐	☐

3.2 Please tick only one box to indicate the effectiveness of the use of the above risk identification techniques in your organisation to identify the potential risks associated with highway construction infrastructure projects in Nigeria

Risk identification Techniques	Effectiveness of the techniques in this projects			
	Not at all effective	Slightly effective	Effective	Very effective
Historical Data	☐	☐	☐	☐
Checklists	☐	☐	☐	☐
Brainstorming	☐	☐	☐	☐
Intuition/judgement	☐	☐	☐	☐
Interview	☐	☐	☐	☐
Consulting expert	☐	☐	☐	☐
Others				

3.3 Please tick only one box in each case to indicate the extent of the use of the following risk analysis techniques in your organisation to analysed the identified risks associated with highway construction infrastructure projects in Nigeria

Risk analysis Techniques	**Usage of risk analysis techniques in this project**			
	Never used	Seldom used	Often used	Always used
Qualitative analysis	☐	☐	☐	☐
Quantitative analysis	☐	☐	☐	☐
Consulting experts	☐	☐	☐	☐
Use of computers and other modelling	☐	☐	☐	☐
Others	☐	☐	☐	☐

3.4 Please tick only one box in each case to indicate the effectiveness of the use of the above risk analysis techniques in your organisation to analyse the identified risks associated with highway construction infrastructure projects in Nigeria

Risk analysis Techniques	**Effectiveness of the risk analysis techniques in this project**			
	Not at all effective	Slightly effective	Effective	Very effective
Qualitative analysis	☐	☐	☐	☐
Quantitative analysis	☐	☐	☐	☐
Consulting experts	☐	☐	☐	☐
Use of computers and other modelling	☐	☐	☐	☐
Others	☐	☐	☐	☐

3.5 Please tick only one box in each case to indicates the extent of which the following risk response techniques are used in your organisation to handle risks associated with highway construction infrastructure projects in Nigeria.

Risk response techniques	**Usage of risk response techniques in this project**			
	Never used	Seldom used	Often used	Always used
Reduce the possibility of occurrence	☐	☐	☐	☐
Reduce the consequences	☐	☐	☐	☐
Avoid the risk	☐	☐	☐	☐
Transfer the risk	☐	☐	☐	☐
Retain the risk	☐	☐	☐	☐
Share the risk	☐	☐	☐	☐
Others	☐	☐	☐	☐

3.6 Please tick only one box in each case to indicate the effectiveness of the use of the above risk response techniques to handle risks associated with highway construction infrastructure projects in Nigeria.

Risk response techniques	**Effectiveness of the usage of risk response techniques in this project**			
	Never used	Seldom used	Often used	Always used
Reduce the possibility of occurrence	☐	☐	☐	☐
Reduce the consequences	☐	☐	☐	☐
Avoid the risk	☐	☐	☐	☐
Transfer the risk	☐	☐	☐	☐
Retain the risk	☐	☐	☐	☐
Share the risk	☐	☐	☐	☐
Others	☐	☐	☐	☐

3.7 Are there any other areas of risk management or challenges in highway construction infrastructure projects in Nigeria that have not be covered that you would like to discuss----------
---

Thank you for your time and contribution to my research

Appendix 2: Test of normality for the dataset

			Kolmogorov- Smirnov[a]		Shapiro-Wilk	
Risk factor coding	Skewness	Kurtosis	Statistic	Sig. p value	Statistic	Sig. p value
HRI 1	-.416	-.655	.219	.000	.900	.000
HRI 2	-.414	-.318	.219	.000	.893	.000
HRI 3	-.786	.317	.299	.000	.844	.000
HRI 4	-.116	-.517	.242	.000	.870	.000
HRI 5	-.549	-.406	.204	.000	.874	.000
HRI 6	-1.037	1.557	.266	.000	.822	.000
HRI 7	-.240	-.392	.261	.000	.857	.000
HRI 8	.174	-.573	.244	.000	.873	.000
HRI 9	.145	-.791	.220	.000	.888	.000
HRI 10	.174	-.723	.197	.000	.896	.000
HRI 11	-.049	-.773	.176	.000	.914	.000
HRI 12	-.090	.003	.266	.000	.883	.000
HRI 13	.091	-.221	.223	.000	.898	.000
HRI 14	.174	-.305	.212	.000	.907	.000
HRI 15	.343	.087	.225	.000	.887	.000
HRI 16	.148	-.550	.193	.000	.904	.000
HRI 17	-.353	-.504	.228	.000	.888	.000
HRI 18	.159	-.467	.198	.000	.903	.000
HRI 19	.254	-.740	.179	.000	.909	.000
HRI 20	-.737	.077	.275	.000	.854	.000
HRI 21	-.298	-.534	.244	.000	.863	.000
HRI 22	-.210	-.812	.220	.000	.875	.000
HRI 23	.145	-.739	.188	.000	.905	.000
HRI 24	.324	-.490	.196	.000	.906	.000
HRI 25	.358	-.858	.208	.000	.874	.000
HRI 26	.034	-.144	.243	.000	.895	.000
HRI 27	.182	-.307	.222	.000	.901	.000
HRI 28	.032	-.611	.179	.000	.911	.000
HRI 29	.111	-.632	.181	.000	.900	.000
HRI 30	.229	-.534	.228	.000	.895	.000
HRI 31	.932	.349	.314	.000	.829	.000
HRI 32	.500	-.307	.223	.000	.896	.000
HRI 33	.520	-.534	.236	.000	.890	.000
HRI 34	-.033	-.771	.176	.000	.912	.000
HRI 35	-.412	-.536	.231	.000	.899	.000

Note: The p values .00 and .00 from Shapiro-Wilk test of normality are both less than 0.05 which imply that it is assumed that the risk factors are not normally distributed. If the Shapiro-Wilk p Value test is greater than 0.05 it can be assumed that the data is normally distributed but this is not the case here.

Appendix 3: Kruskal Wallis test of the selected procurement methods

Selected procurement methods	Ranks Type of organisation	N	Mean Rank
Traditional procurement methods	Government	28	70.66
	International Contractor	43	68.13
	Local Contractor	24	44.79
	Consultant	31	68.81
	Joint Venture	2	70.00
	Total	128	
Design and Build procurement methods	Government	28	53.89
	International Contractor	43	68.27
	Local Contractor	24	81.56
	Consultant	31	57.48
	Joint Venture	2	36.00
	Total	128	
Management Contracting procurement methods	Government	28	65.43
	International Contractor	43	55.17
	Local Contractor	24	82.25
	Consultant	31	63.79
	Joint Venture	2	50.00
	Total	128	
Construction Management procurement methods	Government	28	60.57
	International Contractor	43	59.97
	Local Contractor	24	82.46
	Consultant	31	61.63
	Joint Venture	2	46.00
	Total	128	
Public Private Partnerships (PPP) procurement methods	Government	28	61.88
	International Contractor	43	69.90
	Local Contractor	24	64.67
	Consultant	31	61.06
	Joint Venture	2	36.50
	Total	128	

Appendix 4: case study protocol interviews for the selected case studies

Risk Management Framework for Highway Construction Infrastructure Projects in Nigeria

The research aims to develop a new risk management framework to improve the management of highway construction infrastructure projects in Nigeria

To fulfil the above aim, the following specific objectives will be pursued:

- To gain the state-of-the-art knowledge in risk management involving civil engineering construction infrastructure projects
- To identify and analyse the important risks associated with highway construction infrastructure projects in Nigeria
- To investigate the risk management processes and techniques currently used in highway construction projects in Nigeria and evaluate their effectiveness
- To develop the new risk management framework, to improve the management of the identified and analyse key risks
- To evaluate the newly developed risk management framework

The information provided will be vital to this research work, especially to develop a new risk management framework to improve the management of highway construction infrastructure projects in Nigeria. Be assured that your responses will be anonymous and confidential following the University's Research Code of Practice.

In appreciating your kind help, I will be happy to send you an executive summary of the report when the study is completed if you wish to have one.

Thank you for your time and contribution to my research.

Yours Faithfully,

Akoh, Sani Reuben

PhD Research Student

Supervisors:

Professor Ming Sun & Professor Stephen Ogunlana

Section 1: General Background Information

1.1 Please tell me about your years of experience in highway construction infrastructure projects in Nigeria----------

1.2 Can you give me a brief description of this project? ----------

1.3 What role do you play in this project? (e.g., project manager, site engineer, contractor etc.) ----------

1.4 What is the estimated start, finish and final completion date of this project?

1.5 Please tell me about the estimated and the final cost of this project ----------

1.6 How is this project funded? ----------

1.7 Can you tell me about the procurement and contract methods used for this project? -

---

1.8 How is the performance of this highway project based on the following factors: completion time, cost, quality, environmental sustainability and stakeholder management----------

1.9 How would you describe the management of risk in this particular project based on your experience and responsibility within the highway construction infrastructure projects in Nigeria?----------

1.10 In your opinion, is there is a formal requirement for the management of risk in this project? Please explain. ----------

Section 2: Identification of major risk factors affecting the performance of highway construction infrastructure projects in Nigeria

2.1 Are there any risk factors affecting the performance of this project based on your experience and responsibility within the highway construction infrastructure in Nigeria? Please explain.

2.1 Please tell me about the consequences (impacts) of each of the risk factors identified above on the performance of this very highway construction infrastructure projects. (Hint: use very high, high, medium, low and very low to explain)

Section 3: Investigation of risk management processes and techniques currently used in highway construction infrastructure projects in Nigeria and their effectiveness

3.1 Did you at any stage of this project identify the potential risks that might affect its performance? If yes, please tell me more about the different stages of this project that you have identified the risks.

3.2 Do you keep record of the identified risks? How?

3.3 Tell me about risk identification tools and techniques you have always used in identifying risks in this project?

3.4 How did you use the above techniques? (E.g. periodical risk review meeting?)

3.5 How effective are these tools/techniques in identifying potential risk from your experience in this project?

3.6 Do you still perform risk analysis after the identification process is complete? ------ If yes, how? At which stages?

3.7 Please tell me more about risk analysis tool/techniques you have always used to analyse the identified risk in this project----------

---

3.8 How effective are these tools/techniques from your experience in this project?--------

---

3.9 How did you respond to the risks identified and analysed in this project?----------
---

3.10 Please tell me more about risk management actions you have used to respond to risks in this project. From your experience in this project how effective are these actions you have taken toward risks in this project?----------
---

3.11Do you encounter any barriers or difficulties in implementing risk management in this project? If yes what are they?----------
---

--

3.12 How best, in your opinion, can these barriers be overcome?----------
---

-

2.13 How can each of the major risks identified in 2.1 above be effectively managed to improve the performance of highway construction infrastructure project in Nigeria?------
---

3.14 Are there any other areas of risk management or challenges in this very infrastructure project that have not be covered that you would like to discuss?----------
---

Thank you for your time and contribution to my research

Appendix 5: Risk management plan template for Nigerian Highway Projects (Based on the principle of: Caltrans 2012 &2007; PM1 2008)

Risk management plan

This document explains how risk management will be structured and undertaken for highway construction projects in Nigeria. The risk management plan consists of but is not limited to defining: risk management objectives, roles and responsibilities, process and procedure, frequency of review and reporting, budgeting, risk categories, definitions of risk possibility of occurrence and consequences, reporting format and tracking.

Project name:
Project ID:
Project Location:
Project Sponsor:
Main Contractor:
Consultant:
Project Manager:
Date:
Version:

Risk management plan approval

The signatories below confirmed they have reviewed the risk management plan for the above named highway project in Nigeria. Any amendments to this risk management plan will be coordinated with and approved by the same signatories or their assigned representative. Project manager, project sponsor, contractor and consultant are recommended to be the authorised signatories.

Signature:	Signature:
Print Name:	Print Name:
Title:	Title:
Role:	Role:
Date:	Date:
Signature:	Signature:
Print Name:	Print Name:
Title:	Title:
Role:	Role:
Date:	Date:

Appendix: Risk management plan template sample: continued

Risk management objectives

Risk management encourages the project team to take suitable actions to:

- Decrease the negative impacts on project scope, cost, schedule and quality
- Exploit opportunities to improve the project's objectives with lower cost, shorter duration, enhanced scope and higher quality
- Reduce management crises

Roles and responsibilities

Roles and responsibilities of the Nigerian highway project delivery team regarding risk management planning, identification, analysis, responses strategies, review and monitory will be explained in this section. The project managers, project delivery team members (including contractors, consultants & the client) and the project risk manager should be involved in the risk management activities.

Project risk management roles and responsibilities

Roles	Responsibilities
Project Managers	▪ Integrate resources and time needed to implement the risk management plan in the project budget and schedule ▪ Develop, communicate and implement risk management plan ▪ Develop and update the risk register with the support of the Project Team and integrate it into the work plan ▪ Ensure proactive response to all risks and opportunities that will impact the successful delivery of the project. ▪ Produce risk management reports for sponsors ▪ Schedule and conduct project risk meetings. ▪ Monitor and update risks. ▪ Ensure quality of the risk data in the risk register. ▪ Track and monitor the effectiveness of risk response actions. ▪ Recommend training on risk management skills for project team as often as required
Project Delivery Team Member	▪ Identify the risks and describe them (e.g., political, corruption, etc.) ▪ Evaluate the possibility of the risks occurrence & assign descriptive rating (very low, low, medium, high, very high) ▪ Evaluate the consequences of risks on project cost, time, quality, environmental sustainability and stakeholder management & assign descriptive rating as above ▪ Assist to identify risk owner and develop risk response strategies ▪ Document risk response strategies and report to project manager for integration in risk management updates. ▪ Communicate with project manager about newly-identified risks,

	risk analysis, and retirement of risks.
Project Risk Manager	▪ Support the project manager to develop and update the risk management plan and the risk register ▪ Promote and direct risk management for the project. ▪ Schedule and conduct project risk meetings ▪ Perform risk monitoring and updating ▪ Ensure quality of the risk data in the Risk Register ▪ Document risk response actions ▪ Track and monitor the effectiveness of risk response actions ▪ Track and monitor the effectiveness of risk response actions. ▪ Produce risk management reports for the project manager ▪ Report to the project manager on all matters related to risk management ▪ Compile the lessons learned in the area of risk management

Processes and procedures

This explains how risk management will be implemented for particular highway project in Nigeria. It mainly explains how to approach, plan and implement all activities regarding risk management for a particular highway project in Nigeria.

Frequency of risk management meetings and review of the project risks

Meetings for the purpose of discussing and making decisions on the project risk are scheduled as:

Weekly----------Bi-weekly----------Monthly----------other----------

The risk management identification, analysis, responses, review and monitoring process will occur throughout the whole phases of the project life cycle. A full review and update of risk register will occur at the commencement of each successive phase of the project.

Risk identification Tools & Techniques to be used

Nigerian highway project delivery team and project risk management team should use any combination of: checklists, brainstorming, historical data, interviewing and consulting expert to identify potential risk that might affect the objectives of the project at its stage of development.

Risk analysis methods to be used

Qualitative risk analysis will be used to analyse the identified risk affecting the performance of Nigerian highway construction projects

Risk reporting format

State how the outputs of the risk management processes will be documented analysed and communicated. It explains the content and format of the risk register as well as any other risk reports needed. It also explains risk related reports and their format that will be adopted to communicate the project risks to the interested project sponsors including stakeholders. It is recommended that a copy of risk register template should be attached to the risk management plan.

Tracking

Document how risk activities will be recorded for the benefit of the current project as well as for future needs and lessons learned.

Budgeting

This section explains how to allocate resources, estimate funds required for the management of risk by the project risk management team.

Risk categories

The risk category provides a structure that ensures a comprehensive procedure of systematic risk identification to a consistent level of details and contributes to the efficiency and quality of the identify risk process. A risk categorization framework in form of a simple list of risk categories or a Risk Breakdown Structure can be used to describe risk categories.

Appendix 6: Risk register template for highway construction projects in Nigeria (Based on the principle of experienced gained from Transport Scotland, UK; Caltrans 2012)

Sample of Project Risk Register Template for Highway Construction projects in Nigeria

Project Name:

Project Location:

Project Manager:

Risk IDENTIFICATION				RISK ANALYSIS			RISK RESPONSE				Post Mitigation Analysis			
Risk ID	Category	Descriptions	Current Status	Possibility 1-5	Consequence 1-5	Consequence Score	Strategy	Response Actions	Risk Owner	Updated	Possibility 1-5	Consequemce 1-5	Consquence Score	Date Last Reviewed
H1	Political	Project being cancelled due to change in ruling party		4	4	16	Mitigate	Establish & keep strong tie with top government officials and politicians	PM	01/01/017	2	4	8	

Appendix 6: Risk register template for highway construction projects in Nigeria: continued

Entering data into the Risk Register

The information discussed below provides a guide on how to enter data into the column of the sample risk register provided.

- **Risk ID**: Enter a unique identification number/code for the risk
- **Category**: choose one of the categories for the risk (Appendix B), e.g., Political, Natural.
- **Descriptions:** Provide a statement or description of the event and its potential consequences on the project should this risk occur as shown in the above sample
- **Current status**: If necessary discuss what is currently known about the risk
- **Rating of the possibility of occurrence of risk**: choose 1 – 5 as a measure of the importance of risk for response actions where 1 = very low; 2 = low; 3 = medium; 4 = high & 5 = very high
- **Rating of the consequences of risk occurring:** Choose the consequence rating from 1 – 5 as discussed above
- **Consequence score:** Enter the product of the possibility of risk occurring and its corresponding consequence
- **Strategy:** Enter the suitable risk response strategy. In this case, mitigate
- **Response actions:** Provide a brief description of the response action to decrease the possibility of occurrence or the consequence of an adverse effect of the project risk to tolerable threshold
- **Risk owner:** Write the name of the project risk management team member assigned to the risk
- **Updated:** Enter the date the risk was created
- **Date last reviewed:** Make any amendments and additions to the risk and write the revision date into the date last reviewed column.

Appendix 7: Risk Categorization Framework

Proposed highway risk classification (35 risk factors used for questionnaire)

Risk classification	Risk factor level	Risk factor sub-level
External	**Political**	Unstable government
		Project being cancelled due to change in ruling party
		Strong political interference
		Expropriation /Nationalization
	Corruption	Government officials demand bribe /unjust reward
	Economic	Exchange rate fluctuation
		Inflation/interest rate fluctuation
	Social/cultural	Level of public opposition to projects
		Poor relationship with community
	Land	Landowner unwilling to sell
		Land acquisition and compensation problems
	Natural	Inclement weather
		Adverse ground conditions
	Force majeure	Terrorism attack
		Flood
	Legal	Lack of legal regulatory framework
	Technology	Weak regulatory & monitoring regime
		Unavailability of special equipment
		Failure of major constr. equipment & Unavailability of spare parts
Internal	**Financial**	Project funding challenge
	Construction	Construction time delay
		Construction cost overrun
	Design	Defective design, error and rework
		Availability of design details
	Procurement	Inappropriate procurement methods]
	Operational	High maintenance cost
	Management	Poor communication within different parties
		Lack of quality control and monitoring
		Subcontractors' incompetence
		Poor competence of labourers
	Resource	Shortage of experts in highways
		Shortage of skilled labourers
		Shortage/unavailability of materials
	Third party	Lack of commitment between parties
	Relationship	Lack of joint risk mechanism by parties

Appendix 8: Definition of risk possibility and consequence rating

Definition of possibility and consequence ratings of a risk on key highway project objectives in Nigeria					
Rating	1 (Very low)	2 (Low)	3 (Medium)	4 (High)	5 (Very high)
Cost	Insignificant cost increase	< 5 % cost increase	5 - 10% cost increase	10 - 20% cost increase	> 20% cost increase
Time	Insignificant lapses	< 1 month lapses	1 - 3 month-lapses	3 - 6 month-lapses	> 6 month-lapses
Quality	Insignificant quality deficiency	No safety issues, deficiencies accepted by project team	No safety issues, deficiencies need PM approval	Quality may be accepted through mitigation	Unaccepted quality
Scope	Insignificant scope decrease	Variations in project limits with < 5 % cost increase	Variations in project limits with 5 - 10% cost increase	Sponsor disagreed that scope satisfied purpose & need	Scope does not satisfy purpose & need
Possibility	1 - 9%	10 - 19%	20 - 39%	40 - 59%	60 - 99%

Appendix 9: Risk matrix for highway construction projects in Nigeria

Risk possibility and Consequence Matrix for highway construction projects in Nigeria						
Possibility Rating	5: Very high					
	4: High					
	3: Medium					
	2: Low					
	1: Very low					
		1: Very low	2: Low	3: Medium	4: High	5: Very high
Consequence rating						

Red zone signifies high importance, yellow is medium importance, and blue is low importance. The aggregate of the possibility number and the consequence number define the risk score, e.g. for a risk having medium possibility and a high consequence it is in the red zone and its consequence score is 12.

Appendix 10: Proposed mitigation measures for top 9 highway construction project risks in Nigeria

Risk code	Risk level/ Factor grouping	Top 9 Key risks identified	Mitigation measures (Mm)/strategies	Representative literature
HRCR 20	Economic & Financial F8	Project funding challenge	**M1**: Ensure sufficient funds before project commences	(Case study)
			M2: Develop a clear, suitable plan & visualise contingency fund	(Wang et al., 2004; Zou et al., 2007)
			M3: Project owner to secure standby financing	(Wang et al., 2004; Zou et al., 2007)
			M4: Finance the project via international institutes (e.g., World Bank)	(Lam, 1999;Wang et al., 2004)
			M5: Establish independent project monitoring team to control cost and schedule	(Case study; Zou et al., 2007)
HRCR 21	Third party F6	Construction time delay	**M6**: Employ competent project manager	(Wang et al., 2004; ICE 2005; Zou et al., 2007)
			M7: Ensure competent contractor & subcontractor	(Bing et al., 1999; Zou et al., 2007)
			M8: Select contractors with provable delivery record	(ICE, 2005)
			M9: Establish a clear, suitable plan and control on schedule and cost	(Case study & Wang et al., 2004)
			M10: Be prepared to change the contractor/Or PM	(UK experience)
			M11: Guarantee bonus for early completion	(Lam 1999; Ling & Loon Lim, 2007, Guo et al., 2014 & Tang et al., 2007)
			M12: Provide security package (e.g. performance bond) to guide against delay	(Lam 1999; Wang et al., 2004, Ling & Loon Lim, 2007
			M13: Establish independent project monitoring team to control cost and quality	(Case study; Lam 1999; Bing et al., 1999)
HRCR 3	Political F7	Political interference	**M14:** For international contractors, establish JV with domestic partners such federal government agencies	(Case study; Wang et al.,2004; Bing et al., 2004)
			M15: Establish & keep strong tie with top government officials and politicians	(Wang et al., 2004; Ling & Hoang, 2010)
			M16: Get insurance for political risks	(Case study; Lam, 1999; Wang et al., 2004; Ling & Hoang, 2010)
			M17: Good legal system to guide against political interferences	(Case study)

HRCR 6	Economic & financial F8	Exchange rate fluctuation	**M18:** Prepare contingency fund	(Wang et al., 2004)
			M19: Get Federal government assurances of exchange rate, for instance, fixed for long term duration or less fluctuation	(Wang et al., 2004)
			M20: Award contract in the same currency as the source of funds	(Ling & Loon Lim, 2007)
			M21: Price product and services in a stable foreign currency	(Ling & Hoang, 2010, Wang et al., 2004
			M22: Ensure adequate cash reserve for working capital	(Case study, Ling & Hoang, 2010, Wang et al., 2004)
HRCR 7	Economic & financial F8	Inflation/interest rate fluctuation	**M23**: Ensure adequate cash reserve for working capital	(Ling & Hoang 2010, Wang et al., 2004
			M24: Get payment and performance bonds from domestic and international banks	(Lam, 1999 & Wang et al., 2004
			M25: Finance the project via international institutes (e.g., World Bank)	(Wang et al., 2004
			M26: Make provision for extension or compensation in contract clause for payment	(Wang et al., 2004)
			M27: Fund project from sources not affected by interest rate hikes in Nigeria	(Ling & Hoang 2010)
			M28: Allow adequate contingency in the project budget	(Wang et al., 2004Ling & Hoang 2010,
HRCR 22	Construction F2	Construction cost overrun	**M29**: Ensure accurate measure and price bills of quantity during bidding process	(Wang et al., 2004
			M30: Establish a clear, suitable plan and control schedule and cost	(Case study & Wang et al.,2004)
			M31: Integrate upsurge clauses for interest, inflation rates and deferment in contract clause for payment	(Wang et al., 2004)
			M32: Negotiate fixed loan contract with lending banks	(Wang et al., 2004) (Wang et al., 2004, Ling & Loon Lim, 2007)
			M33: Negotiate fixed price with material and labour suppliers	(Wang et al., 2004, Ling & Loon Lim, 2007
			M34: Engage reputable local suppliers and labour to reduce cost	(Case study & Lam, 1999)
			M35: Negotiate for full exemption from duties on imported machinery and material	(Lam 1999)
			M36: Provide security package (e.g. material and labour bond) to guide against cost overrun	(Lam 1999) (Wang et al., 2004)

			M37: Employ competent project manager	(Case study & Lam,1999)
			M38: Establish independent project monitoring team to control progress and quality	(Wang et al., 2004) (Case study &Wang et al., 2004)
HRCR 5	Corruption F4	Government officials demand bribe /unjust reward	**M39**: Establish & keep strong tie with top government officials and key stakeholders	(Wang et al., 2004)
			M40: For Int'l contractors, establish JV with domestic partners such federal government agencies & insist on having reliable people on key positions within the JV	(Case study & Wang et al., 2004)
			M41: In case of JV, all parties should have corporate accounting standard and employ an independent accountant	(Wang et al., 2004)
			M42: Get all important approvals on time to eliminate opportunity for corruption	(Wang et al., 2004)
			M43: Negotiate for one-stop agency for all approval	(Wang et al., 2004)
			M44: Work directly with business link	(Wang et al., 2004)
			M45: Make & reserve budget for unavoidable spending	(Wang et al., 2004)
			M46: Continuous awareness training to key management personnel to deal with corruption	(Case study & Wang et al., 2004)
HRCR 1	Political F7	Unstable government	**M47:** Develop own contingency plans for inevitable political uncertainty	(Wang et al., 2004)
			M48: Get support from foreign firm's home office during political unrest or insurgency	(Wang et al., 2004)
			M49: Get insurance for political risks	(Case study, Wang et al., 2004;Ling & Hoang, 2010)
HRCR 2	Political F7	Project being cancelled due to change in ruling party	**M50:** Establish & keep strong tie with top government officials and politicians	(Bing et al., 1999, Wang et al., 2004)
			M51: Seek integration of termination or delay clause in contract	(Wang et al., 2004)
			M52: Get insurance for political risks	(Case study, Lam, 1999; Ling & Hoang, 2010, & Wang et al., 2004)
			M53: Seek privately funded project	
			M54: Engage on short duration projects	(Ling & Hoang, 2010)
			M55: Make provision for clauses for delays and additional payment in contract	(Ling & Hoang, 2010) (Wang et al., 2004)

Appendix 11: Evaluation feedback interview questions

Risk Management Framework for Highway Construction Projects in Nigeria

By
Akoh, Sani R

Supervisors:

Professor Ming Sun

&

Professor Stephen Ogunlana

Centre of Excellence in Sustainable Building Design, School of Energy, Geo-Science, Infrastructure & Society

Framework Evaluation

Section 1: General background information

Please print your name (optional)----------

Please print your email address (optional)

Please state your current job title----------

Please state if you belong to any professional membership (e.g. NSE, MNITE, COREN, NIS, etc.) ----------

Please state your years of working experience in highway construction projects----------
---

Please select from the options below that best indicate the type of organisation you are working for.

Government	International Contractor	Local Contractor	Consultant	Joint Venture	Other (Specify)
☐	☐	☐	☐	☐	☐

1.1 Please select from the options below that best indicate the number of highway projects you have been involved in over the past three years or more

None	1 - 3	4 - 6	7 - 10	Other (specify)
☐	☐	☐	☐	☐

Section 2: The Framework Validation

Please find attached herewith 'Risk management framework for highway construction projects in Nigeria' in **Figure 8-1**. The guidelines for the application of the framework are explained afterward. As part of the validation process, kindly evaluate the framework following the validation processes below.

Please kindly comment on the clarity and comprehensiveness of the overall framework-
---

Please kindly comment on the practical relevance and suitability of the framework to the Nigerian highway construction project risk management.----------
---

What is your view on each of the specific guidelines/instructions for the application of each of the phases of the framework?----------
---

How useful or relevant is the proposed risk register (**Appendix 6**) for managing risks in Nigerian highway construction projects?----------
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Do you consider any of the proposed mitigation measures (**Appendix 10**) for the top nine most critical risks in Nigerian highway construction projects that **is/are** not relevant that should be removed? Please comment----------
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Please comment if there are any limitations or weaknesses of the framework----------
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Please kindly identify other potential areas where you think the framework can be used-
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Please provide your general overview and any suggestion (if any) for improvement of the framework----------
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Are you aware of any existing risk management framework for highway construction projects in Nigeria? If yes, please provide more details to include any difference between the existing risk management framework in Nigeria and the one I have developed----------
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Thank you for your time and contribution to my research.